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ART. XXIV.—*On American Geological History:*—Address before the American Association for the Advancement of Science, August, 1855, by JAMES D. DANA.

[IN republishing this address, the author has added various notes in illustration of the text. The circumstances of the occasion on which it was delivered precluded the introduction of detailed explanations. Moreover, as the author aimed to give the history of principles or the grander steps of progress in American geology, rather than a full exhibition of its successive discoveries, he unavoidably omitted the mention of many names which are honorably associated with the science in this country. Both obligations to others as well as himself and the science, have therefore prompted the introduction of the notes.

New Haven, September 10, 1856.]

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In selecting a topic for this occasion, I have not been without perplexity. Before an Association for the Advancement of Science,—science in its wide range,—a discourse on the progress of science in America for the past year would seem legitimate. Yet it is a fact that the original memoirs in most departments, published within that period, would make a very meagre list. Moreover, it is too much to expect of any one to roam over others' territories, lest he ignorantly gather for you noxious weeds. I have, therefore, chosen to confine myself to a single topic, that

of Geology; and I propose, instead of simply reviewing recent geological papers, to restrict myself to some of the general conclusions that flow from the researches of American geologists, and the bearing of the facts or conclusions on geological science. I shall touch briefly on the several topics, as it is a subject that would more easily be brought into the compass of six hours than one. In drawing conclusions among conflicting opinions, or on points where no opinion has been expressed, I shall endeavor to treat the subject and the views of others in all fairness, and shall be satisfied if those who differ from me shall acknowledge that I have honestly sought the truth.

In the first place, we should have a clear apprehension of the intent or aim of Geological Science. It has been often said, that Geology is a *history*, the records of which are written in the rocks: and such is its highest department. But is this clearly appreciated? If so, why do we find text-books, even the one highest in authority in the English language, written back end foremost,—like a History of England commencing with the reign of Victoria. In history, the phases of every age are deeply rooted in the preceding, and intimately dependent on the whole past. There is a literal unfolding of events as time moves on, and this is eminently true of Geology.

Geology is not simply the science of rocks, for rocks are but incidents in the earth's history, and may or may not have been the same in distant places. It has its more exalted end,—even the study of the progress of life from its earliest dawn to the appearance of man; and instead of saying that fossils are of use to determine rocks, we should rather say that the rocks are of use for the display of the succession of fossils. Both statements are correct; but the latter is the fundamental truth in the science.

From the progress of life, geological time derives its division into Ages, as has been so beautifully exhibited by Agassiz. The successive phases in the progress of life are the great steps in the earth's history. What if in one country the rocks make a consecutive series without any marked interruption between two of these great ages, while there is a break or convenient starting-point in another; does this alter the actuality of the ages? It is only like a book without chapters in one case, and with arbitrary sections in another. Again, what if the events characteristic of an age—that is, in Geology, the races of plants or animals—appear to some extent in the preceding and following ages, so that they thus blend with one another? It is but an illustration of the principle just stated, that *time is one*. Ages have their progressive development, flowing partly out of earlier time, and casting their lights and shadows into the far future. We distinguish the ages by the culmination of their grand characteristics, as we would mark a wave by its crest.

Divisions of time *subordinate* to the great ages will necessarily depend on revolutions in the earth's surface, marked by abrupt transitions, either in the organic remains of the region, or in the succession of rocks. Such divisions are not universal. Each continent has its own periods and epochs, and the geologists of New York and the other States have wisely recognized this fact, disregarding European *stages* or subdivisions. This is as true a principle for the Cretaceous and Tertiary, as for the Silurian and Devonian. The usurpation of Cromwell made an epoch in English annals; not in the French or Chinese. We should study most carefully the records, before admitting that any physical event in America was contemporaneous with a similar one in Europe. The unity in geological history is in the progress of life and in the great physical causes of change, not in the succession of rocks.

The geological ages, as laid down by Agassiz, are the following:—I. The AGE OF FISHES, including the Silurian and Devonian; II. The AGE OF REPTILES, embracing from the Carboniferous through the Cretaceous; III. The AGE OF MAMMALS, the Tertiary and Post-tertiary; IV. The AGE OF MAN, or the recent era;—*fishes* being regarded as the highest and characterisic race of the first age; *reptiles* of the second; and *mammals* of the third.

More recent researches abroad, and also the investigations of Prof. Hall in this country, have shown that the supposed fish remains of the Silurian are probably fragments of Crustacea, if we except those of certain beds near the top of the Silurian; and hence the *Age of Fishes* properly begins with the Devonian. What then is the Silurian? It is pre-eminently the AGE OF MOLLUSKS.

Unlike the other two Invertebrate sub-kingdoms, the *Radiate* and *Articulate*, which also appear in the earliest fossiliferous beds, the *Molluscan* sub-kingdom is brought out in all its grander divisions. There is not simply the type, but the type analyzed or unfolded into its several departments, from the Brachiopods and Bryozoa up to the highest group of all, the Cephalopods. And among these Cephalopods, although they may have been inferior in grade to some of later periods, there were species of gigantic size, the shell reaching a length of ten or twelve feet. The Silurian is therefore most appropriately styled the *Molluscan Age*.

The Palæozoic Trilobites belong to the lower tribe of Crustacea, and Crustacea rank low among Articulates. Moreover, Crustacea (and the Articulata in general) did not reach their fullest development until the Human Era.

The Radiata were well represented in the Silurian periods; but, while inferior to the Mollusca as a sub-kingdom, only corals

and crinoids, the lower fixed or vegetative species, with rare exceptions, occur in the Silurian or Molluscan Age.

The Articulata and Radiata thus begin early, but with only the lower forms in each, and neither is a leading class in any age.

Viewing the history, then, *zoölogically*, the ages are—the Age of Mollusks, of Fishes, of Reptiles, of Mammals, of Man.

We may now change the point of view to the Vegetable Kingdom. The ages thence indicated would be three:—

I. The *Age of Algæ*, or marine plants, corresponding to the Silurian and Devonian.

II. The *Age of Acrogens*, or flowerless trees, that is, the Lepidodendra, Sigillariæ, and Calamites,—corresponding to the Coal Period and Permian; a name first proposed by Brongniart, and which may still be retained, as it is far from certain that the Sigillariæ and Calamites are most nearly related to the Coniferæ.

III. The *Age of Angiosperms*, or our common trees, like the Oak, Elm, &c., beginning with the Tertiary.

The interval between the second and third of these ages is occupied mainly by Coniferæ, the Pine tribe, and Cycadeæ, the true Gymnosperms, species of which were abundant in the Coal Period, and have continued common ever since. The Coniferæ, in the simplicity of their flowers and their naked seeds, are next akin to the Acrogens or flowerles trees. Although in the main a flowerless vegetation, for the few supposed remains of flowers observed abroad have been recently referred to undeveloped leaf-buds, it appears probable from the observations of Dr. Newberry, that there were some true flowers over the Ohio prairies,—apparently monocotyledonous, and related to the Lily tribe. But no traces of Palms or monocotyledonous trees have been found in the coal fields of this country.

Combining the results from the animal and vegetable kingdoms, we should introduce the Age of Acrogens, for the Coal Period and Permian, between the Age of Fishes and Age of Reptiles,—a space in time zoölogically occupied by the overlapping of these two ages.*

* This Age, would perhaps be more correctly styled, the *Age of Conifers*, as Conifers, a higher group than Acrogens, were among the earliest of all land plants, occurring in the upper Devonian as well as Carboniferous; and the ages in other cases are named from the superior group of species. Yet as the Acrogens were especially characteristic of the era, and the Conifers have their fullest development in the present age, the name above given seems to be preferable:—unless it prove true that the Sigillariæ and Calamites are actually related to the Coniferæ as urged by Brongniart. *Zoologically*, the age has some title to the name, *Age of Amphibians*. But before it closed, true reptiles had appeared. It is a significant fact that the Amphibians in some cases appear to have approached true reptiles, as much as some of the genera of Acrogens the Conifers. An interesting example of this, from the coal formation of Ohio, has recently been mentioned by Dr. J. Wyman, (Tenth Meeting Amer. Assoc. at Albany).

The order then reads, the Age of MOLLUSKS, of FISHES, of ACROGENS or Coal plants, of REPTILES, of MAMMALS, of MAN.

The limits of these ages are as distinct as history admits of; their blendings where they join, and the incipient appearance of a type before the age it afterwards characterizes fully opens, are in accordance with principles already explained.

The reality of progress from lower to higher forms is not more strongly marked in these names, properly applied, than in the rocks. If, hereafter, mammals, reptiles, or fishes, are found a little lower than now known, it will be changing but a sentence in the history,—not the grand idea which pervades it.

A theory lately broached by one whose recent death has caused universal grief to science, supposes that the Reptilian was an age of diminished life, between the two extremes in time, the Palæozoic and Mammalian Ages. But, in fact, two grand divisions of animals, the Molluscan and Reptilian, at this time reach their climax and begin their decline, and this is the earliest instance of the highest culmination of a grand zoölogical type.

Preceding the Silurian or Molluscan Age, there is the AZOIC AGE, or *age without animal life*. It was so named by Murchison and De Verneuil; and was first recognized in its full importance and formally announced in this country, in the Geological Report of Messrs. Foster and Whitney, although previously admitted in an indefinite way by most geologists.*

It embraces all the lowest rocks up to the Silurian, for much of the lowest granite cannot be excluded.

The actual absence of animal life in the so-called Azoic Age in this country is rendered highly probable, as Foster and Whitney show, by the fact that many of the rocks are slates and sandstones, like fossiliferous Silurian rocks, and yet have no fossils; and moreover, the beds on this continent were uplifted and folded, and to a great extent crystallized on a vast scale, before the first Silurian layers were deposited. A grand revolution is here indicated, apparently the closing event of the early physical history of the globe.†

* Report on the Geology of the Lake Superior Land District, by J. W. Foster and J. D. Whitney, U. S. Geologists; Part II, The Iron Regions together with General Geology. Senate Executive Document, No. 4, Special Session, March, 1851. Ordered to be printed, March 13, 1851. 406 pp. 8vo, with many plates, and a large geological map and section.

† Foster and Whitney observe, (loc. cit. pp. 7, 26, 132,) that at Chippewa Island (in the Menomonee river, near 45½° N, 88° W,) the Potsdam sandstone lies on the upturned Azoic slates. At White Rapids, lower down the stream, the same sandstone rests on the tilted edges of the Azoic quartz rock. Near Presqu' Isle (not far from 46° 30′—46° 35′ N, 87° 33° W), a similar contact of the nearly horizontal Potsdam and the vertical quartz rock is seen.

The Azoic of this continent was well studied and defined at a still earlier date by the distinguished geologist of Canada, Sir William E. Logan. In his Annual

As plants may live in water too hot or impure for animals, and moreover, since all nature exemplifies the principle that the earth's surface was occupied with life as soon as fitted, and with the highest forms the conditions of the time allowed, we may reasonably infer that there may have been in Azoic times marine species and plant-infusoria, forms adapted to aid in the earth's physical history; and thus vegetation may have long preceded animal life on the globe.*

After these general remarks on the divisions of Geological time, I now propose to take up the characteristic features and succession of events in American Geology.

Report for 1846, 1847, and that for 1848, he points out several examples of the Silurian covering the contorted Azoic, and his subsequent surveys have added to the facts of this kind. They occur north of the lakes Huron and Superior, and along and to the north of the St. Lawrence. Moreover in the vicinity of the lakes just mentioned, he found the Azoic divided into two unconformable groups, a *lower*, since called by him the *Laurentian*, and an upper, the *Huronian*; the former consisting of granite, syenite, gneiss, hornblende rock, hypersthene rock, crystalline limestones, etc.; the latter of diorite, slates, white and red sandstones, conglomerates, limestones, the whole much intersected by trap and metalliferous veins containing native copper, &c., and having a thickness in some places, probably of 9000 to 12000 feet.

Sections representing the nearly horizontal Lower Silurian overlying the Azoic, as observed by him in the vicinity of the St. Lawrence northeast of Lake Champlain, are figured in the Quarterly Journal of the Geological Society of London, for 1852, pp. 203 and 206.

In the progress of the Geological Survey of New York, commencing in 1836, the fact that the crystalline rocks of Northern New York were older than the Silurian was early shown, but good sections illustrating the superpositions of the two were not given.

At the meeting of the American Association at Cincinnati in 1851, when Foster and Whitney first presented their views on the Azoic, Prof. Mather stated that he had traced the continuation of the system nearly to the sources of the Mississippi and on the waters of the St. Peters,—a region since reported on by Dr. D. D. Owen, (Geol. Survey of Wisconsin, Iowa and Minnesota, 4to, 1852); Dr. H. King contributed observations on the Azoic or iron-mountain region of Missouri, (p. 194, Amer. Assoc. Rep. 1851,) indicating the inferiority in position of these rocks to the Silurian, as had been urged by Messrs. Foster and Whitney from the investigations by Mr. Mersch under their direction; and Dr. Engelmann described related rocks in Arkansas between Little Rock and the Hot Springs.

Professors W. B. and H. D. Rogers refer to Azoic Rocks as found in the Appalachians; but no instances of the superposition of the lowest Silurian in those regions on other *non-conformable* beds have yet been published; and it is a question whether the metamorphic rocks are all related to those of New England in age, or partly of this era of metamorphism and partly Azoic.

* The evidence with respect to the existence of plants in the Azoic Age, though by no means positive, is stronger than here stated.—In the *first* place, there are *limestones* among the folded strata; and as limestones of later ages were almost wholly of organic origin, these of Azoic rocks *may* also have been so.—2nd, *Graphite* is a common mineral in some of the crystalline rocks, and graphite is known to result from the alteration by heat of the carbon of plants.—3d, The Huronian rocks, according to Mr. Logan, actually contain some small seams of anthracite.—4th, Vegetation, as it is directly or indirectly the food of animals, should necessarily have preceded animal life.—With reference to the statement in the text above, it should be noted that vegetation has been observed growing among the Geysirs of Iceland, in waters having a temperature of 180° F.; and the writer has seen a case of similar kind, on Luzon, one of the Philippines, where the temperature was 160° F. This is much beyond the limit, which the eggs of animals can endure and survive.

In the outset we are struck with the comparative simplicity of the North American continent, both in form and structure. In *outline*, it is a triangle, the simplest of mathematical figures; in *surface*, it is only a vast plain lying between two mountain ranges, one on either border, the Appalachian from Labrador to Alabama on the east, the Rocky Mountains on the west; and on its *contour* it has water, east, west, north, and south.

Observe too that its border heights are proportioned to the size of the oceans. A *lofty* chain borders the Pacific, a *low* one the narrow Atlantic, while the small Arctic sea is faced by no proper mountain range.

This principle, that the highest mountains of the continents face the largest oceans, is of wide application, and unlocks many mysteries in physical geography. South America lies between the same oceans as North America: it has its eastern low range, its western Andes; and as the oceans widen southward, the continent is there pinched up almost to a narrow mountain ridge. It differs from North America in having a large expanse of ocean, the Atlantic, on the north; and, correspondingly, it has its northern mountain ridges. The world is full of such illustrations, but I pass them by.

This simplicity of ocean boundary, of surface features, and of outline, accounts for the simplicity of geological structure in North America. We may make indeed the wider statement, that all these qualities are some way connected with the positions and extent of the oceans, they seeming to point to the conclusion, that the subsidence of the oceanic basins had determined the continental features; and that farther, both results were involved in the earth's gradual refrigeration, and consequent contraction.

America has thus the simplicity of a single evolved result. Europe, on the contrary, is a world of complexities. It is but one corner of the Oriental continent,—which includes Europe, Asia, and Africa,—and while the ocean bounds it on the north and west, continental lands inclose it on the south and east. It has ever been full of cross purposes. American strata often stretch from the Atlantic west beyond the Mississippi; and east of the Rocky Monntains, it has but one proper mountain range of later date than the Silurian. Europe is much broken up into basins, and has mountains of all ages: even the Alps and Pyrenees are as recent as the Tertiary.

This wide contrast accounts for the greater completeness or generality of American revolutions, the more abrupt limits of periods, and clearer exhibition of many geological principles.

The geological structure of this country has been made known through the combined researches of a large number of investigators. The names of MACLURE, SILLIMAN, EATON, lead off the

roll; HITCHCOCK, the Professors ROGERS, the well-known GEOLOGISTS of the NEW YORK SURVEY, also, OWEN, PERCIVAL, MORTON, CONRAD, TUOMEY, and many others, have made large contributions to the accumulating results. Yet the *system* may be said to have been mainly laid open by four sets of observers,—MORTON for the Cretaceous; CONRAD for the Tertiary; the NEW YORK GEOLOGISTS for the Palæozoic strata; and the Professors ROGERS for the Carboniferous beds and the Appalachians.

The succession of Silurian and Devonian rocks in the State of New York is the most complete in the country, and it was well for the science that its rocks were so early studied, and with such exactness of detail. The final display of the Palæontology by Mr. James Hall has given great precision to the facts, and the system has thereby become a standard of comparison for the whole country, and even for the world.

This accomplished, the Carboniferous rocks were still to be registered, and the grand problem of New England Geology solved. The Professors Rogers, in the surveys of Pennsylvania and Virginia, followed out the succession of strata from the Devonian through the Coal Period, and thus, in a general way, completed the series. And more than this, they unravelled with consummate skill the contortions among the Appalachians, bringing order out of confusion, and elucidating a principle of mountain-making which is almost universal in its application. They showed that the Silurian, Devonian, and Carboniferous strata, which were originally laid out in horizontal layers, were afterwards pressed on to the north-westward, and folded up till the folds were of mountain height, and that thus the Appalachians had their origin; and that also, by the escaping heat of those times of revolution, extensive strata were altered, or even crystallized.*

* As I have already remarked, many names are above omitted which have contributed largely to our knowledge of American Geology.

While Dr. MORTON was the first to distinguish the North American *Cretaceous* beds, and pursued his researches with great energy and skill, they have been largely studied also by LYELL in different localities on the east and south, by NICOLLET and recently SHUMARD, HAYDEN, MEEK and HALL, on the beds west of the Mississippi, by RÖMER in Texas, TUOMEY in South Carolina, H. D. ROGERS and others in New Jersey, J. W. BAILEY with reference to microscopic species, and J. LEIDY for Vertebrate Remains.

The *Tertiary* has been investigated by LYELL along both the eastern and southern border; also in different localities by MORTON, M. TUOMEY, F. S. HOLMES, C. S. HALE, I. LEA, H. D. and W. B. ROGERS, RÖMER, J. D. DANA and W. P. BLAKE for the tertiary of the Pacific coast, BAILEY for minute species, HARLAN, OWEN, MÜLLER, PROUT, LEIDY, WYMAN and GIBBES, for Vertebrate fossils; while these and many other authors have published on the *post-tertiary* deposits and organic remains.

The *Silurian* and *Devonian* systems have occupied the attention of nearly all who have written on American Geology, in the East or West, among whom, there are:—HALL, MATHER, VANUXEM, EMMONS, CONRAD, De VERNEUIL of Paris, the Professors ROGERS, Messrs. WHITNEY and FOSTER, D. D. OWEN, C. T. JACKSON, D. HOUGHTON

This key soon opened to us a knowledge of New England geology, mainly through the labors of Prof. Hall, and also of Professor H. D. Rogers, following up the survey of President Hitchcock; and now the so-called primary rocks, granite, gneiss, schists, and crystalline limestones, once regarded as the oldest crystallizations of a cooling globe, are confidently set down as for the most part no older than the Silurian, Devonian, and Carboniferous of New York and Pennsylvania.*

Let us now briefly review the succession of epochs in American geological history.

The Azoic Age ended, as was observed, in a period of extensive metamorphic action and disturbance,—in other words, in a vast revolution. At its close, some parts of the continent were left as dry land, which appear to have remained so, as a general thing, in after times; for no subsequent strata cover them. Such

of Michigan, G. Troost and lately J. M. Safford of Tennessee, J. Greene, J. Locke, C. Whittlesey, I. A. Lapham, G. C. Swallow, J. G. Norwood, B. F. Shumard, besides the investigators in Canada, Sir W. E. Logan, J. Bigsby, J. W. Dawson, T. S. Hunt and others.

The *Carboniferous* formation was early studied in many of its details by Dr. S. P. Hildreth. But the successive strata of the whole formation from the Devonian through the Subcarboniferous and Coal Measures, were first systematized by the Professors Rogers, though without yet marking out in any of their publications the subdivisions of the coal measures themselves and the characteristic fossils of each, as had been done for the Devonian and Silurian by the New York Geologists. Other researches on the coal beds have been made by R. C. Taylor and J. P. Leslie in Pennsylvania, J. Hall, D. D. Owen, and others in the states of the Mississippi valley, J. S. Newberry on the fossil plants and fishes of the Ohio coal measures, Hitchcock and C. T. Jackson on the coal beds of Rhode Island; Dawson, Lyell, Jackson, etc., on the New Brunswick and Nova Scotia beds; Lea, Wyman, Leidy, Lyell and Dawson on Reptilian and other carboniferous fossils.

The parallelism of the rock formations of the east and west has been determined mainly through the researches of Prof. Hall, who first presented his views on the subject in 1841, and continues still his investigations. The examinations of De Verneuil, besides defining the limits of our Devonian, also contributed much on this subject.

The red sandstone and trap regions of the Triassic or Jurassic period, which occur in the Connecticut valley and in other valleys parallel with the Atlantic border to the south, and also to the north beyond Nova Scotia, have been specially investigated by D. Olmsted, E. Hitchcock, J. G. Percival, Professors Rogers, E. Emmons, J. W. Dawson, C. T. Jackson, F. Alger; and as regards the vertebrate fossils, by E. Hitchcock, J. Deane, W. C. Redfield, J. H. Redfield, J. Wyman, J. Leidy, I. Lea, and Prof. Owen of London; and the plants, by the Professors Rogers, C. T. F. Bunbury, and E. Hitchcock, Jr.

* The labors of Sir W. E. Logan have thrown great light upon New England geology, and are giving a definiteness to our knowledge hitherto unattained. He is finding that some of the crystalline New England rocks which stretch north into Canada, are there uncrystalline and fossiliferous, and thus is putting the question of age beyond doubt. The Berkshire limestone has thus been determined at its northern extremity as well as in New Jersey; the calcareous mica slate of western Vermont, has been shown to be Upper Silurian in age, it being uncrystalline limestone towards Gaspé, partially metamorphic and still containing distinct traces of fossils in the valleys of the river St. François and Lake Memphremagog, and farther south becoming more crystalline as well as calcareous and losing all indications of fossils. Prof. T. S. Hunt of the Canada Survey, has brought other facts to bear on this subject.

are a region in Northern New York, others about and beyond Lake Superior, and a large territory stretching from Labrador westward, as recognized by Messrs. Foster and Whitney and Prof. Hall, and the geologists of Canada.*

The Silurian or Molluscan Age next opens. The lowest rock is a sandstone, one of the most widely spread rocks of the continent, stretching from New England and Canada south and west, and reaching beyond the Mississippi,—how far is not known. And this first leaf in the record of life is like a title page to the whole volume, long afterwards completed; for the nature of the history is here declared in a few comprehensive enunciations.

1. The rock, from its thin, even layers, and very great extent, shows the wide action of the ocean in distributing and working over the sands of which it was made; and the ocean ever afterward was the most active agency in rock-making.

2. Moreover, ripple-marks, such as are made on our present sea-shores or in shallow waters, abound in the rock, both through the east and west, and there are other evidences also of moderate depths, and of emerged land.† They all announce the wonderful fact, that even then, in that early day, when life first began to light up the globe, the continent had its existence,—not in embryo, but of full-grown extent; and the whole future record is but a working upon the same basis, and essentially within the same limits. It is true that but little of it was above the sea, but equally true that little of it was at great depths in the ocean.

3. Again, in the remains of life which appear in the earliest layers of this primal rock, three of the four great branches of the Animal Kingdom are represented,—Mollusks, Trilobites among Articulates, and Corals and Crinoids among Radiates,—a sufficient representation of life for a title-page. The New

* The Azoic lands, above the ocean at this time, recognized by Messrs. Foster and Whitney in the Report referred to, were that of the Azoic region, between Lake Superior and Hudson's Bay, that between Lake Superior and Lake Michigan, the Azoic Island of Northern New York; and the facts they state would add the Missouri iron-mountain region, and the metamorphic region of Arkansas as possibly other islands. Mr. Whitney has more recently shown that the occurrence of great masses of specular or magnetic iron is proof that the metamorphic rocks containing them are of the Azoic age or præ-Silurian.

On the Geological map of northern North America, published by Mr. Isbister in the Quarterly Journal of the Geological Society for 1855, xi, 497, the Azoic is shown to extend in a narrow band northwestward from Canada to the Arctic sea between Hudson's Bay and the Winnipeg line of small lakes.

† Other marks of shallow water alluded to are wave lines, and the oblique lamination characterising many subordinate layers in the rock,—the latter due to changing currents, like the ebb and flow of tides, or variations in tidal or other currents, or the occasional action of storm waves. This oblique lamination as well as ripple marks, occurs abundantly in the Potsdam sandstone of northern New York (Emmons's Geol. Rep. p. 104, 130); in Canada (Logan's Reports, 1851–52, p. 12 and elsewhere); south of Lake Superior (Foster and Whitney, loc. cit. p. 118); in the Upper Mississippi (Owen, Survey of Wisconsin, etc., p. 48); in Pennsylvania and Virginia (Professors H. D. and W. B. Rogers).

York beds of this rock had afforded only a few mollusks; but the investigations of Owen and others have added the remaining tribes; and this diversity of forms is confirmed by Barrande in his Bohemian researches.*

Among the genera, while the most of them were ancient forms that afterwards became extinct, and through succeeding ages thousands of other genera appeared and disappeared, the very earliest and most universal was one that now exists,—the genus *Lingula*,—thus connecting the extremes of time, and declaring most impressively the unity of creation. Mr. T. S. Hunt, of the Canada Geological Survey, recently discovered that the ancient shell had the anomalous chemical constitution of bones, being mainly phosphate of lime; and afterwards he found in a modern Lingula the very same composition,—a further announcement of the harmony between the earliest and latest events in geological history.†

This earliest sandstone,—called in New York the Potsdam sandstone,—and the associated Calciferous sand-rock, mark off the *First Period* of the Molluscan Age,—the POTSDAM PERIOD, as it may be called.‡

Next followed the TRENTON PERIOD,—a period of limestones, (the Trenton limestone among them,) equal to the earlier beds in geographical limits, and far more abundant in life, for some beds are literally shells and corals packed down in bulk; yet the species were new to the period, the former life having passed away; and even before the Trenton Period closed, there were three or four epochs of destruction of life followed by new creations. The formation of these limestone beds indicates an in-

* The *Lingula prima* and *L. antiqua* are the Mollusks referred to as occurring in the New York beds. The discoveries by Owen, in the vicinity of the Falls of the St. Croix, Minnesota, and on the Mississippi, were published by him in his Report on a *Geological Reconnoisance of the Chippewa Land District of Wisconsin and the Northern part of Iowa*, Washington (Senate Document), 1848, p. 14, and subsequently in his quarto Report on Wisconsin, &c., of 1852. The fossils he mentions in the latter work are species of *Lingula*, *Obolus*, *Orbicula*, *Orthis*, several forms of Crinoids, and large Trilobites referred mostly to the new genus *Dikelocephalus*. The species as named are, *Lingula antiqua*, *L. prima*, *L. pinnaformis* Owen, *L. ampla* Owen, *Obolus Apollinis* (?), *Orbicula prima* O., *Dikelocephalus Minnesotensis* O., *D. Miniscaencis* O., *D.* (?) *Iowensis* O., *D. granulosus* O., *D. Pepinensis* O., *Lonchacephalus Chippewaensis* O., *Crepicephalus* (?) *Wisconsensis* O., *C. Miniscaensis* O.,

Prof. W. B. Rogers in the last number of this Journal (p. 296), announced the discovery of the Trilobite *Paradoxides Harlani* of Green (*P. spinosus* of Barrande) in slates ten miles south of Boston, Mass., a species found by Barrande in his protozoic or earliest fossiliferous rock of Bohemia,—thus adding a new species to the American protozoic Fauna, and the largest yet discovered, the length of some of the specimens exceeding a foot. Prof. E. Emmons announces also (Meeting of Amer. Assoc. in August last, at Albany) the discovery of a large Cyathophylloid coral in the lowest fossiliferous rocks of North Carolina. The exact age of the rock however is yet uncertain.—See a notice beyond in this number.

† Am. Jour. Sci., [2], xvii, 235, (1854).

‡ Through the comparisons of Prof. Hall, it is now well known that the "Lower Magnesian Limestone" of the west and a sandstone with which it alternates, correspond to the Calciferous sandrock of New York.

crease in the depth of the continental seas,—an instance of the oscillation of level to which the earth's crust was almost unceasingly subject through all geological ages until the present.

After the Trenton Period, another change came over the continent, and clayey rocks or shales were formed in thick deposits in New York, and south,—the Utica slate and Hudson River shales,—while limestones were continued in the West. This is the HUDSON PERIOD; and with it, the *Lower Silurian* closed.*

The seas were then swept of their life again, and an abrupt transition took place both in species and rocks. A conglomerate covered a large part of New York and the States south, its coarse material evidence of an epoch of violence and catastrophe: and with this deposit the *Upper Silurian* began.

The Upper Silurian has also its three great periods,—the NIAGARA, the ONONDAGA, and the LOWER HELDERBERG, besides many subordinate epochs,—each characterized by its peculiar organic remains,—each evidence of the nearly or quite universal devastation that preceded it, and of the act of omnipotence that reinstated life on the globe,—each, too, bearing evidence of shallow or only moderately deep waters when they were formed; and the Onondaga Period—the period of the New York salt rocks—telling of a half-emerged continent of considerable extent.

Another devastation took place, and then opened, as De Verneuil has shown, the Devonian Age or Age of Fishes. It commenced, like the Upper Silurian, with coarse sandstones, evidence of a time of violence; these were followed by another grit rock, whose few organic remains show that life had already reappeared. Then another change,—a change evidently in depth of water,—and limestones were forming over the continent, from the Hudson far westward: the whole surface became an exuberant coral reef, far exceeding in extent, if not in brilliancy, any modern coral sea; for such was a portion, at least, of the UPPER HELDERBERG Period.

Again there was a general devastation, leaving not a trace of the former life in the wide seas; and where were coral reefs, especially in the more eastern portion of the continental seas, sandstones and shales accumulated for thousands of feet in thickness, with rarely a thin layer of limestone. Thus passed the HAMILTON, CHEMUNG and CATSKILL Periods, of the Devonian age. The life of these regions, which in some epochs was ex-

* Prof. Hall, in connection with J. D. Whitney, has recently made the important observation, that the Galena or lead-bearing limestone, which is the upper member of the Trenton group, is separated from the Niagara limestone in Iowa and Wisconsin by thick strata of Hudson River shales, giving a prolongation to these shales before unsuspected. He had previously, with Mr. Whitney, traced these shales around the north side of Lake Huron and Lake Michigan to Pointe aux Baies, and thence along Green Bay to Lake Winnebago. These shales are however partly replaced by limestone in Ohio, etc.

ceedingly profuse, was three or four times destroyed and renewed:—not renewed by a re-creation of the same species, but by others; and although mostly like the earlier in genera, yet each having characteristic marks of the period to which it belonged. And while these Devonian Periods were passing, the first land plants appeared, foretellers of the age of verdure, next to follow.

Then come vast beds of conglomerate, a natural opening of a new chapter in the record; and here it is convenient to place the beginning of the Carboniferous Age, or the Age of Acrogens. Sandstones and shales succeeded, reaching a thickness in Pennsylvania and New Jersey, according to the Professors Rogers, of thousands of feet; while in the basin of the Ohio and Mississippi, in the course of this era, the Subcarboniferous limestone was forming from immense Crinoidal plantations in the seas.*

Another extermination took place of all the beautiful life of the waters, and a conglomerate or sandstone was spread over the encrinital bed: and this introduced the true coal period of the Carboniferous Age;—for it ended in leaving the continent, which had been in long-continued oscillations, quite emerged. Over the regions where encrinites were blooming, stretch out vast wet prairies or marshes of the luxuriant coal vegetation. The old system of oscillations of the surface still continues, and many times the continent sinks to rise again,—in the sinking, extinguishing all continental life, and exposing the surface to new depositions of sandstone, clays, or limestone, over the accumulated vegetable remains; in the rise, depopulating the seas by drying them up, and preparing the soil for verdure again; or at times, convulsive movements of the crust carrying the seas over the land, leaving destruction behind. And thus, by repeated alternations, the coal period passes, some six thousand feet of rock and coal-beds being formed in Pennsylvania, and fourteen thousand feet in Nova Scotia.

I have passed on in rapid review, in order to draw attention to the series or succession of changes, instead of details.† So brief an outline may lead a mind not familiar with the subject to regard the elapsed time as short; whereas to one who follows out the various alternations and the whole order of events, the idea of *time immeasurable* becomes almost oppressive.

* This Subcarboniferous limestone is sparingly represented in Pennsylvania among the sandstones and shales; but according to Prof. W. B. Rogers it increases to the southward, and in Virginia acquires a thickness of 1500 to 2000 feet.

† The names given to the subdivisions of the Palæozoic rocks are the same that have been laid down by the New York Geologists, whose assiduous and successful labors in a territory of so great geological importance, entitle them to pronounce upon the nomenclature of American Rocks. I have varied from the ordinary use of the terms only in applying them to the periods and epochs when the rocks were formed, so as to recognize thereby the historical bearing of geological facts. The

Before continuing the review, I will mention some conclusions which are here suggested.

I. In the first place, through the periods of the Silurian and Devonian, at twelve distinct epochs at least, the seas over this American continent were swept of all or nearly all existing life, and as many times they were repeopled: and this is independent of many partial exterminations and renewals of life that at other times occurred.

If Omnipotent Power had been limited to making *monads* for after development into higher forms, many a time would the whole process have been utterly frustrated by hot water, or by mere changes of level in the earth's crust, and creation would have been at the mercy of dead forces. The surface would have required again and again the sowing of monads, and there would have been a total failure of crops after all; for these exterminations continue to occur through all geological time into the Mammalian Age.

II. Again: I have observed that the continent of North America has never been the deep ocean's bed, but a region of

Periods and Epochs thus made out are as follows—excluding minor subdivisions which may make Sub-epochs, and not attempting to give the parallel subdivisions for the West. On this subject, the volumes and papers by Prof. Hall especially should be consulted.

I. SILURIAN AGE.

1. *Lower Silurian.*

1. Potsdam Period.—1st Epoch. Potsdam sandstone: 2nd. Calciferous sandrock.
2. Trenton Period.—1st Epoch. Chazy limestone; 2nd. Birdseye; 3d. Black River; 4th. Trenton.
3. Hudson Period.—1st Epoch. Utica Shale; 2nd. Hudson River Shale. (Hudson River Shale and Blue limestone of Ohio in parts of the west.)

2. *Upper Silurian.*

1. Niagara Period.—1st Epoch. Oneida Conglomerate; 2nd. Medina Sandstone; 3d. Clinton Group; 4th. Niagara Group.
2. Onondaga Period.—1st Epoch. Galt limestone; 2nd. Onondaga Salt Group.
3. Lower Helderberg Period.—Limestones. (Statement of epochs here omitted).

II. DEVONIAN AGE.

1. Oriskany Period.—1st Epoch. Oriskany Sandstone; 2nd. Cauda-galli Grit.
2. Upper Helderberg Period.—1st Epoch. Schoharie Grit; 2nd. Upper Helderberg group.
3. Hamilton Period.—1st Epoch. Marcellus Shales; 2nd. Hamilton group; 3d. Genesee Slate.
4. Chemung Period.—1st Epoch. Portage; 2nd. Chemung group.
5. Catskill Period.—Catskill Red Sandstones and Shales. (No. IX. of Rogers.)

III. CARBONIFEROUS AGE.

1. Subcarboniferous Period.—1st Epoch, Conglomerates, Sandstones and Shales (with some coal seams); 2nd. Sandstones, Shales and Carboniferous limestone. Nos. X. and XI. of Rogers.
2. Carboniferous Period.—1st Epoch, Millstone Grit; 2nd. Lower Coal Measures; 3d. Upper Coal Measures. Nos. XII. and XIII. of Rogers.
3. Permian Period.—Probably unrepresented in Eastern North America, except by the events of the Appalachian revolution.

comparatively shallow seas, and at times emerging land; and was marked out in its great outlines even in the earliest Silurian. The same view is urged by De Verneuil, and appears now to be the prevailing opinion among American geologists. The depth at times may have been measured by the thousand feet, but not by miles.

III. During the first half of the lower Silurian era, the whole east and west were alike in being covered with the sea. In the first or Potsdam Period, the continent was just beneath or at the surface. In the next or Trenton Period, the depth was greater, giving purer waters for abundant marine life. Afterwards, the East and West were in general widely diverse in their formations; limestones, as Mr. Hall and the Professors Rogers have remarked, were generally in progress over the West, that is, the region, now the great Mississippi Valley, beyond the Appalachians, while sandstones and shales were as generally forming from northeastern New York south and southwest through Virginia. The former, therefore, has been regarded as an area of deeper waters, the latter as, in general, shallow, when not actually emerged. In fact, the region toward the Atlantic border, afterwards raised into the Appalachians, was already, even before the Lower Silurian era closed, the higher part of the land: it lay as a great reef or sand-bank, partly hemming in a vast continental lagoon, where corals, encrinites and mollusks grew in profusion, thus separating more or less perfectly the already existing Atlantic from the interior waters.

IV. The oscillations or changes of level over the continent, through the Upper Silurian and Devonian, had some reference to this border region of the continent: the formations approach or recede from it, and sometimes pass it, according to the limits of the oscillations eastward or westward. Along the course of the border itself there were deep subsidences in slow progress, as is shown by the thickness of the beds. It would require much detail to illustrate these points, and I leave them with this bare mention.

The Hudson River and Champlain valleys appear to have had their incipient origin at the epoch that closed the Lower Silurian; for while the preceding formations cross this region and continue over New England, the rocks of the Niagara and Onondaga Periods (the first two of the Upper Silurian) thin out in New York before reaching the Hudson River. Mr. Logan has recognized the division of America to the northeast into two basins by an anticlinal axis along Lake Champlain, and observes also that the disturbances began as early, at least, as the close of the Lower Silurian, mentioning, too, that there is actually a want of conformity at Gaspé between the beds of the Upper

and Lower Silurian,—another proof of the violence that closed the Lower Silurian era.*

But let us pass onward in our geological record.

All the various oscillations that were in slow movement through the Silurian, Devonian, and Carboniferous Ages, and which were increasing their frequency throughout the last, raising and dipping the land in many alternations, were premonitions of the great period of revolution,—so well elucidated, as already observed, by the Professors Rogers,—when the Atlantic border, from Labrador to Alabama, long in preparation, was at last folded up into mountains, and the Silurian, Devonian, and Carboniferous rocks were baked or crystallized. No such event had happened since the revolution closing the Azoic Period. From that time on, all the various beds of succeeding ages up to the top of the Carboniferous had been laid down in horizontal or nearly horizontal layers, over New England as well as in the West,—for the continent from New England westward, we have reason to believe, was then nearly a plain, either above or below the water; there had been no disturbances except some minor uplifts: the deposits, with small exceptions, were a single unbroken record, until this Appalachian revolution.†

This epoch, although a time of vast disturbances, is more correctly contemplated as an epoch of the slow measured movement of an agency of inconceivable power, pressing forward from the ocean towards the northwest; for the rocks were folded up without the chaotic destruction that sudden violence would have been likely to produce. Its greatest force and its earliest beginning was to the northeast. I have alluded to the disturbance

* This Eastern border of the American continent, then in process of formation over the present Appalachian region from Labrador and Canada southwestward, lay deeper to the south than to the north. In Canada and the Azoic of Northern New York, there was land out of water, forming its northern limit. From thence it stretched on with its gradually deepening waters, though varying constantly with the oscillations. The thickness of many of the sedimentary beds passing southward from the New York Azoic prove this increasing depth to have been a general fact; and it is corroborated by a statement made by Prof. W. B. Rogers (meeting of Amer. Assoc. in August last at Albany), that the subcarboniferous sandstones and shales containing but little limestone in Pennsylvania, were replaced by beds of the subcarboniferous limestone which to the south in Virginia reach a great thickness (see note to page 317)—the limestones indicating clearer and somewhat deeper waters. The early disturbances and uplifts *in the northeast* near Gaspé and along the Hudson valley also accord with this view.

Again, the position of the Azoic dry land in Canada and of the sedimentary rocks south and southwest, shows us that the Continent in those early times received the northern Labrador current,—which would have kept by the shore as now, along the eastern border of this Azoic,—over New Brunswick and Nova Scotia, and that thence its natural course would have been southwest over the Appalachian region, where the sandstones and shales were extensively accumulated; and therefore its aid in making these deposits can scarcely be doubted.

† It is urged by Prof. Hall and others that the Carboniferous beds in the west lie unconformably on the beds below. But the disturbance indicated was not one of bold flexures or uplifts.

between the Upper and Lower Silurian beds of Gaspé, to the north. Another epoch of disturbance, still more marked, preceded, according to Mr. Logan, the Carboniferous beds in those northeastern regions; and New England, while a witness to the profound character and thoroughness of the Appalachian revolution, attests also to the greater disturbance towards its northern limits. Some of the Carboniferous strata were laid down in Rhode Island as clay and sand and layers of vegetable debris: they came forth from the Appalachian fires as we now have them, the beds contorted, the coal layers a hard siliceous anthracite or even graphite in places, the argillaceous sands and clays crystallized as talcose schist, or perhaps gneiss or syenite.

These very coal-beds, so involved in the crystalline rocks, are part of the proof that the crystallization of New England took place after the Coal Era. Fossils in Maine, Vermont, Canada, and Massachusetts add to the evidence. The quiet required by the continent for the regular succession and undisturbed condition of the rocks of the Silurian, Devonian, and Carboniferous formations, shows that in neither of these ages could such vast results of metamorphic action and upheaval have taken place.

The length of time occupied by this revolution is beyond estimate. Every vestige of the ancient Carboniferous life of the continent disappeared before it. In Europe, a Permian Period passed, with its varied life; yet America, if we may trust negative evidence, still remained desolate. The Triassic Period next had its profusion of living beings in Europe, and over two thousand feet of rock; America through all, or till its later portions, was still a blank: not till near the beginning of the Jurassic Period do we find any traces of new life, or even of another rock above the Carboniferous.

What better evidence could we have than the history of the oscillations of the surface from the earliest Silurian to the close of the Carboniferous Age, and the final cresting of the series in this Appalachian revolution, that the great features of the continent had been marked out from the earliest time? Even in the Azoic, the same northeast and southwest trend may be observed in Northern New York and beyond Lake Superior, showing that, although the course of the great Azoic lands was partly east and west, the same system of dynamics that characterized succeeding ages was then to some extent apparent.

The first event in the records after the Appalachian revolution, was the gathering up of the sands and rolled fragments of the crystallized rocks and schists along the Atlantic border into beds; not over the whole surface, but in certain valleys, which lie parallel with the Appalachian chain, and which were evidently a result of the foldings of that revolution. The beds are the red sandstones and shales, which stretch on for one hundred

and twenty miles in the Connecticut valley: and similar strata occur in Southeastern New York, in New Jersey, Virginia, North Carolina and Nova Scotia. These long valleys are believed to have been estuaries, or else river courses.

The period of these deposits is regarded as the earlier Jurassic by Professor W. B. Rogers. Dr. Hitchcock supposes a portion of the preceding or Triassic Period to be represented.*

Many of the layers show, by their shrinkage cracks, ripple-marks, and footprints, as others have observed, that they were formed in shallow waters, or existed as exposed mud-flats. But they accumulated till they were over a thousand feet thick in Virginia, and in New England two or three thousand, according to the lowest estimate. Hence the land must have been sinking to a depth equal to this thickness, as the accumulation went on, since the layers were formed successively at or near the surface.

Is it not plain, then, that the oscillations, so active in the Appalachian revolution and actually constituting it, had not altogether ceased their movements, although the times were so quiet that numerous birds and reptiles were tenants of the Connecticut region? Is it not clear that these old valleys, occurring at intervals from Nova Scotia to South Carolina, originally made by foldings of the earth's crust, were still sinking?

And did not the tension below of the bending rocks finally cause ruptures? Even so: and the molten rock of the earth's interior which then escaped, through the crystalline rocks beneath and the overlying sandstone, constitutes the trap mountains, ridges, and dykes, thickly studding the Connecticut Valley, standing in palisades along the Hudson, and diversifying the features of New Jersey and parts of Virginia and North Carolina. The trap is a singularly constant attendant on the sandstone,

* This Red Sandstone, after being known for a while under the name of "Old Red Sandstone," was long called the "New Red Sandstone," it being shown to be above the carboniferous system. The first step towards a nearer determination of its age was made by Mr. J. H. Redfield in a paper on the Fossil Fishes of the Connecticut valley published in 1836, who made it Jurassic (Lias or Oolitic), (Ann. Lyc. N. Hist. N. Y., vol. iv.) Mr. W. C. Redfield added to the facts bearing on this conclusion through discoveries made in New Jersey and Virginia. Prof. W. B. Rogers deduced from the coal plants of the Richmond beds, the same age for those beds, while admitting that other beds of the sandstone might be Triassic. Afterwards on finding the same Posidonia and Cypridæ in North Carolina, in each of the belts in Virginia, in the belt in Pennsylvania near Phenixville, and one plant (Lycopodites Williamsonis) common to Virginia and Massachusetts, he suggested that all the beds were probably Jurassic (Am. J. Sci. [2], xix, 123). Mr. E. Hitchcock, Jr., detected recently a fossil plant (*Clathropteris rectiusculus*, Am. J. Sci. [2], xx, 22), near the middle of the sandstone formation in Massachusetts, and remarks that it indicates the existence of the Lower Jurassic at that place, and also renders it probable that the Triassic may be represented in the inferior beds, as is sustained by Prof. Hitchcock. Prof. Emmons has recently obtained Reptilian Fish, and Molluscan fossils in North Carolina, (communicated to the Amer. Assoc. at Albany in August last,) which are related to those of the Triassic and Jurassic periods. The amount of evidence as far as now understood therefore tends to sustain the view that the Period of the sandstone, while it may cover part of the Triassic, is mainly Jurassic.

and everywhere bears evidence of having been thrown out soon after the deposition of the sandstone, or in connection with the formation of its later beds. Even the small sandstone region of Southbury in Connecticut, has its trap.

Thus ended in fire and violence, and probably in submergence beneath the sea, the quiet plains of the Connecticut valley, where lived, as we now believe, the first birds of creation; kinds that were nameless, until, some countless ages afterwards, President Hitchcock tracked them out, found evidence that they were no unworthy representatives of the feathered tribe, and gave them and their reptile associates befitting appellations.*

Such vast regions of eruptions could not have been without effusions of hot water and steam, and copious hot springs. And may not these heated waters and vapors, rising through the crystalline rocks below, have brought up the copper ores, that are now distributed, in some places, through the sandstone? The same cause, too, may have given the prevalent red color to the rock, and produced changes in the adjoining granite.

After the era of these rocks, there is no other American record during the European Jurassic Period.

In the next or Cretaceous Period, the seas once more abound in animal life. The position of the cretaceous beds around the Atlantic border shows that the continent then stood above the sea very much as now, except at a lower level. The Mississippi valley, which, from the Silurian, had generally been the region of deeper waters, was even in cretaceous times occupied to a considerable extent by the sea,—the Mexican Gulf then reaching far north, even high up the Missouri, and covering also a considerable part of Texas and the Rocky Mountain slope.

An age later, the Cretaceous species had disappeared, and the Mammalian Age (or the Tertiary, its first Period) begins, with a wholly new Fauna, excepting, according to Professor Tuomey, some half a dozen species, about which however there is much doubt. The continent was now more elevated than in the preceding age, and the salt waters of the Mexican Gulf were withdrawn from the region of Iowa and Wisconsin, so as not to reach beyond the limits of Tennessee.†

* Mr. J. Deane of Greenfield was also an early explorer of these tracks, and is now engaged in publishing on the subject, illustrating his memoir with plates of great beauty and perfection.

† The recent investigations of F. B. Meek and Dr. J. V. Hayden, have shown (Proc. Acad. Nat. Sci. Philad., viii, 111, 1856,) that while there is much *fresh-water* tertiary in the Nebraska regions and beyond, there is also about the head waters of the Missouri some *marine* tertiary. The region investigated lies between the 46th and 49th parallels of North latitude and the 100th and 108th degrees of longitude: but it is not yet ascertained whether the body of salt water thus indicated was an isolated area, or an arm from the Mexican Gulf. The shells, (species of Ostrea, Corbula, and Cerithium) do not satisfactorily fix the age of the tertiary, but suggest, the authors say, that it may be the older Eocene. They occur in the same beds with

Two or three times in the course of the Tertiary Period, the life of the seas was exterminated, so that the fossils of the later Tertiary are not identical with any in the earliest beds,—excluding some fish remains, species not confined to the coast waters. The crust of the earth was still oscillating; for the close of the first Tertiary epoch was a time of subsidence; but the oscillation or change of level was slight, and by the end of the Tertiary, the continent on the east stood within a few feet of its present elevation, while the Gulf of Mexico was reduced nearly to its present limits.*

I have thus brought this rapid sketch to the close of the Tertiary, having omitted much of great interest, in order to direct attention to the one grand fact,—that the continent from the Potsdam sandstone, or before, to the Upper Tertiary, was one in its progress,—a single consecutive series of events according to a common law. It is seen, that the great system of oscillations, due to force pressing or acting from the southeast, which reached its climax in the rise of the Appalachians, then commenced a decline. We mark these oscillations still producing great results in the Jurassic Period along the whole eastern border from Nova Scotia to the Carolinas. Less effect appears in the Cretaceous Period; and gradually they almost die out as the Tertiary closes, leaving the Mississippi Valley and the eastern shores near their present level.

Thus were the great features of Middle and Eastern North America evolved; nearly all its grand physical events, including its devastations and the alternations in its rocks, were consequent upon this system of development. Moreover, as I have observed, this system was some way connected with the relative position of the continent and the oceanic basin.

We need yet more definite knowledge of the Pacific border of North America to complete this subject. It is in accordance with the fact that the highest mountains are there, that volcanoes have been there in action; and also that, in the Tertiary Period, elevations of one to two thousand feet took place; and that immediately before the Tertiary, a still greater elevation of the Rocky Mountains across from east to west occurred. The system of changes between the Rocky Mountains and the Pacific has been on a grander scale than on the Atlantic border, and also from a different direction,—and this last is an element for

numerous freshwater shells, species of Melania, Physa, Paludina, Cyrena, and all are such kinds as inhabit fresh and brackish waters. The tertiary deposits of the Bad Lands, or that part where the bones occur, have afforded no evidence of salt water origin; and the same is true of the Lignite beds of the far north. While therefore the tertiary beds are extensive, the marine tertiary, indicating the presence of the sea, as far as present knowledge goes, is quite limited.

* Naming the North American Tertiary Epochs from prominent localities, as in the Palæozoic, they are:—1. The Claiborne, or Older Eocene; 2. The Vicksburg, or Newer Eocene; 3. The Yorktown, or Pliocene and Miocene in one.

whose influence on the general features we cannot yet make full allowance.

Through all this time, central British America appears to have taken little part in the operations; and what changes there were, except it may be, in the Arctic regions, conformed to the system prevailing farther south, for the rocks of the Jurassic Age, like the Connecticut River sandstone, are found as far north as Prince Edward's Island, in the Gulf of St. Lawrence.

But the Tertiary Period does not close the history of the continent. There is another long Period the Post-tertiary,—the period of the Drift, of the Mastodon and Elephant, of the lake and river terraces, of the marine beds on Lake Champlain and the St. Lawrence,—all anterior to the Human Era.

From this time there is a fundamental change in the course of operations. The oscillations are from the north, and no longer from the southeast.

The *drift* is the first great event, as it underlies the other loose material of the surface; and all recognize it as a *northern* phenomenon, connected with northern oscillations.

The upper terrace of the lakes and rivers, and also the marine beds four hundred feet above the level of Lake Champlain, and five hundred above the St. Lawrence, which have been called Laurentian deposits, are marks of a *northern* depression, as no one denies.

The subsequent elevation to the present level again, by stages marked in the lower river terraces, was also *northern*, affecting the region before depressed.

The south felt but slightly these oscillations.

There are thus the following epochs in the Post-tertiary:—the *Drift Epoch;* the *Laurentian Epoch*, an epoch of depression; the *Terrace Epoch*, an epoch of elevation; *three* in number, unless the Drift and Laurentian Epochs are one and the same.

As this particular point is one of much interest in American Geology, I will briefly review some of the facts connected with the drift.

The drift was one of the most stupendous events in geological history. In some way, by a cause as wide as the continent,—and, I may say, as wide nearly as the world,—stones of all sizes, to immense boulders of one or two thousand tons weight, were transported, along with gravel and sand, over hills and valleys, deeply scratching the rocks across which they travelled. Although the ocean had full play in the many earlier ages, and an uneasy earth at times must have produced great convulsions, in no rock strata, from the first to the last, do we find imbedded stones or boulders at all comparable in magnitude with the immense blocks that were lifted and borne along for miles in the Drift epoch.

Much doubt must remain about the origin of the drift, until the courses of the stones and scratches about mountain ridges and valleys shall have been exactly ascertained. The general course from the north is admitted; but the special facts proving or disproving a degree of dependence on the configuration of the land have not yet been sufficiently studied.

One theory, the most prevalent, supposes a deep submergence over New England and the North and West, even to a depth of four or five thousand feet, and conceives of icebergs as floating along the blocks of stone, and at bottom scratching the rocks. Another, that of the Professors Rogers, objects to such a submergence, and attributes the result to an incursion of the ocean from the north, in consequence of an earthquake movement beneath the Arctic Seas.

The idea of a submergence is objected to on the ground that the sea has left no proof of its presence by fossils, sea-shore terraces or beaches.

Unless the whole continent were submerged, of which there is no evidence whatever, there must have been in the Post-tertiary Period an east-and-west line of sea-shore, say across New Jersey, Pennsylvania, Southern Ohio, and the other States west, or still farther south; and yet no such sea-shore marks now exist to trace its outline, although the ocean must have been a portion of the same that had laid up the Cretaceous and Tertiary beds all along the coasts, and, in fact, already contained the oysters and clams and many other species of Mollusks which now exist. Can it be, that, contrary to all the ways of the past, such a grand submergence as this view supposes, placing New England four thousand feet under water, could have transpired without a sea-shore record?

Very many have replied in the affirmative; and one able advocate of this view, who sees no difficulty in the total absence of sea-shore terraces or fossils at all levels above the Laurentian beds, finds in the succeeding epoch sea-shore accumulations in all the terraces of our rivers. Why this wonderful contrast? What withheld the waves from acting like waves in the former case, and gave unbounded license in the latter?

This much, then, seems plain, that the evidence although negative, is very much like positive proof that the land was not beneath the sea to the extent the explanation of the drift phenomena would require.

There are other objections to this view of submergence. If North America were submerged from the southern boundary-line of the drift far into the Arctic regions, this would have made a much warmer climate for the continent than now; if only half-way, then there is another east-and-west shore line to be traced out, before the fact of the submergence can be admitted. Again,

we know how the ice, while a glacier, or along a shore of cliffs, (for all bergs are believed to have once been glaciers,) may receive upon them or gather up heavy blocks of stone, even a thousand tons in weight, and bear them off to distant regions, as now happens in the Northern Atlantic. But we have no reason to believe that the massy foot of a berg could pick up such blocks and carry them twenty miles, to drop them again: and hence the short distance of travel would prove that the bergs were made that short distance to the north, and this implies the existence there of glacier valleys and requires a glacier theory.

But without considering other difficulties, I pass to the inquiry, Whether the lands, if not submerged, were at any higher level than now?

There is evidence of striking character, that the regions or coasts over the higher latitudes, in both the northern and southern hemispheres, were once much elevated above their present condition. The *fiords*, or deep coast channels, scores of miles long, that cut up the coast of Norway and Britain, of Maine, Nova Scotia and Greenland, of Western America from Puget's Sound north, of Southern South America from Chiloe south, of Van Diemen's Land and other southern islands, are all valleys that could not have been scooped out when filled with the ocean's waters as now; that could have been formed only when the land in those high latitudes, north and south, was elevated till their profound depths were nearly or quite dry. Whether this elevation was in the period of the Post-tertiary has not been precisely ascertained. But as they are proof of a north-and-south system of oscillations, the same that was in action in the Drift epoch, and as the cold that such a change would occasion is not very distinctly apparent in the Tertiary period, and much less in the earlier, we have reason for referring the greater part of the elevation to that Drift era, and for believing that the excavation of these fiord valleys was then in progress. Both fiords and drift are alike high-latitude phenomena on all the continents north and south. The change of climate between the Cretaceous and Tertiary, and the absence of Tertiary beds north of Cape Cod, may have been connected with an incipent stage in this high-latitude movement.

However this be, there is other evidence in the cold of the Drift period, of some extraordinary cause of cold. The drift in Europe and Britain is generally attributed to glaciers and icebergs during a period of greater cold than now; and the fact of this greater cold is so generally admitted, that it is common to speak of it as the glacial period. Professor Agassiz, moreover, has urged for this continent the glacial theory.

In a memoir of great research by Mr. Hopkins of Cambridge, England, the able author maintains that this glacial cold might

have been produced over Europe, partly at least, by a diversion of the Gulf Stream from its present position. He seems in his paper to attribute too much effect to the Gulf Stream, and too little to the prevailing currents of the atmosphere. But, setting this aside, it is unfortunate for the hypothesis, that there is no reason to suppose that America was not then as much in the way of such a diversion as now. The small changes of level which the Tertiary and Post-tertiary beds of the Gulf have undergone, prove that the gate of Darien was early closed, and has since continued closed. America, as facts show, has not been submerged since the Tertiary to receive the stream over its surface. If it had been, it would have given other limits to her own drift phenomena; for it is an important fact that these limits in America and Europe show the very same difference in the climates or in the isothermals as that which now exists.*

On the question of the drift, we therefore seem to be forced to conclude, whatever the difficulties we may encounter from the conclusion, that the continent was not submerged, and therefore that icebergs could not have been the main drift agents: that the period was a cold or glacial epoch, and the increase of cold was probably produced by an increase in the extent and elevation of northern lands. Further than this, in the explanation of the drift, known facts hardly warrant our going.

If, then, the Drift epoch was a period of elevation, it must have been followed by a deep submergence to bring about the depression of the continent already alluded to, when the ocean stood four hundred feet deep in Lake Champlain, and a whale—for his bones have been found by the Rev. Z. Thompson of Burlington—was actually stranded on its shores; and when the upper terrace of the rivers was the lower river flat of the valleys. This submergence, judging from the elevated sea-beaches and terraces, was five hundred feet on the St. Lawrence and Lake Champlain; eighty feet at Augusta, Maine; fifty feet at Lubec; thirty at Sancoti Head, Nantucket; over one hundred at Brooklyn, N. Y.; and two hundred to two hundred and fifty in Central New England, just north of Massachusetts; while south, in South Carolina, it was but eight or ten feet.

But whence the waters to flood valleys so wide, and produce the great alluvial plain constituting the upper terrace, so immensely beyond the capability of the present streams? Perhaps, as has been suggested for the other continent, and by Agassiz for

* Moreover, the Gulf Stream is known to be a deep current, so deep as to be turned around to the northward in part by the submarine slopes of the outer West Indian Islands, and it would have required a submergence of many hundred feet, and moreover a passage quite across the continent into the Arctic seas, to have given the stream a chance over the land: and even then, if the West Indian Islands were not also deeply sunk in the ocean, a large part of the current would still have kept its present track in the Atlantic.

this, from the melting snows of the declining glacier epoch. The frequent absence of fine stratification, so common in the material of this upper terrace, has often been attributed to a glacier origin.

According to this view, the events of the Post-tertiary Period in this country make a single consecutive series, dependent mainly on polar or high-latitude oscillations:—an elevation for the *first* or *Glacial Epoch;* a depression for the *second* or *Laurentian Epoch;* a moderate elevation again, to the present height, for the *third* or *Terrace Epoch.*

The same system may, I believe, be detected in Europe; but, like all the geology of that continent, it is complicated by many conflicting results and local exceptions; while North America, as I have said, is like a single unfolding flower in its system of evolutions.

There is the grandeur of nature in the simplicity to which we thus reduce the historical progress of this continent. The prolonged oscillations of the crust, caused by pressure from the southeast beneath the Atlantic, which reach on through the Palæozoic ages, producing the many changes of level in the Silurian and Devonian, still others of greater frequency in the Carboniferous, and then, as in an outburst of long emprisoned energy, throwing up the range of the Appalachians, with vast effusions of heat through the racked and tortured crust, next go on declining as the Jurassic and Cretaceous Periods pass, and finally fade out in the Tertiary. The northern oscillations, perhaps before in progress, then begin to exhibit their effects over the high temperate latitudes, and continue to the Human Era. The sinking of Greenland, now going on, may be another turn in the movement; and it is a significant fact, that, while we have both there and in Sweden northern changes of level in progress, such great secular movements have nowhere been detected on the tropical parts of the continents.

In deducing these conclusions, I have only stated in order the facts as developed by our geologists. Were there time for a more minute survey of details, the results would stand forth in bolder characters.

The sublimity of these continental movements is greatly enhanced when we extend our vision beyond this continent to other parts of the world. It can be no fortunate coincidence, that has produced the parallelism between the Appalachian system and the grand feature lines of Britain, Norway, and Brazil, or that has covered the north and south alike with drift and fiords. But I will not wander, although the field of study is a tempting one.

In thus tracing out the fact, that there has been a plan or system of development in the history of this planet, do we separate

the Infinite Creator from his works? Far from it: no more than in tracing the history of a plant. We but study the method in which Boundless Wisdom has chosen to act in creation. For we cannot conceive that to act without plan or order is either a mark of divinity or wisdom. Assuredly it is far from the method of the God of the universe, who has filled all nature with harmonies; and who has exhibited his will and exalted purpose as much in the formation of a continent, to all its details, as in the ordered evolution of a human being. And if man, from studying physical nature, begins to see only a Deity of physical attributes, of mere power and mathematics, he has but to look within at the combination of the affections with intellect, and observe the latter reaching its highest exaltation when the former are supreme, to discover proofs that the highest glory of the Creator consists in the infinitude of his love.

My plan, laid out in view of the limited time of a single address, has led me to pass in silence many points that seem to demand attention or criticism; and also to leave unnoticed the labors of many successful investigators.

There are some subjects, however, which bear on general geology, that should pass in brief review.

I. The rock-formations in America may in general be shown to be synchronous approximately with beds in the European series. But it is more difficult to prove that catastrophes were synchronous, that is, revolutions limiting the ages or periods.

The revolution closing the Azoic Age, the *first* we distinctly observe in America, was probably nearly universal over the globe.

An epoch of some disturbance between the Lower and Upper Silurian is recognized on both continents. Yet it was less complete in the destruction of life on Europe than here, more species there surviving the catastrophe; and in this country there was but little displacement of the rocks.

The Silurian and the Devonian Ages each closed in America with no greater revolutions than those minor movements which divided the subordinate periods in those ages. Prof. Hall observes that they blend with one another, and the latter also with the Carboniferous, and that there is no proof of contemporaneous catastrophes giving them like limits here and in Europe.

But after the Carboniferous, came the Appalachian revolution, one of the most general periods of catastrophe and metamorphism in the earth's history. Yet in Europe the disturbances were far less general than with us, and occurred along at the beginning and end of the Permian Period.

From this epoch to the close of the Cretaceous, there were no contemporaneous revolutions, as far as we can discover. But the Cretaceous Period terminates in an epoch of catastrophe which was the most universal on record, all foreign Cretaceous species having been exterminated, and all American, with a few doubtful exceptions.* This third general revolution was the prelude to the Mammalian Age. But there is no time to do this subject justice, and I pass on,—merely adding, on account of its interest to those who would understand the first chapter of Genesis, that there is no evidence whatever in Geology, that the earth, after its completion, passed through a chaos and a six days' creation at the epoch immediately preceding man, as Buckland, in the younger days of the science, suggested, on *Biblical*, not on Geological, ground. No one pretends that there is a fact or hint in Geology to sustain such an idea: on the contrary, it is utterly opposed to it.

II. The question of the existence of a distinct *Cambrian system* is decided adversely by the American records. The Mollusca in all their grand divisions appear in the subdivisions of the Lower as well as Upper Silurian, and the whole is equally and alike the Molluscan or Silurian Age. The term Cambrian, therefore, if used for fossiliferous strata, must be made subordinate to Silurian.

The *Taconic system* of Emmons has been supposed by its author to have a place inferior to the Cambrian of Sedgwick, or else on a level with it. But the investigations of Hall, Mather, and Rogers, and more lately of Logan and Hunt, have shown that the Taconic slates belong with the upper part of the Lower Silurian, being, in fact, the Hudson River shales, far from the bottom of the scale.

III. The American rocks throw much light on the origin of coal. Professor Henry D. Rogers, in an able paper on the American coal-fields, has well shown that the condition of a delta or estuary for the growth of the coal-plants, admitted even now by some eminent geologists, is out of the question, unless the whole continent may be so called; for a large part of its surface was covered with the vegetation. Deltas exist where there are large rivers; and such rivers accumulate and flow where there are mountains. How, then, could there have been rivers, or true deltas of much size, in the Coal Period, before the Rocky Mountains or Appalachians were raised? It takes the Andes to make an Amazon. This remark has a wider application than simply to the Coal Era.

IV. In this connection, I add a word on the idea that the rocks of our continent have been supplied with sands and gravel from

* This catastrophe may not have been violent; it may have been ages in accomplishment; yet it was disastrous to the living tribes over the whole sphere.

a continent now sunk in the ocean. No facts prove that such a continent has ever existed, and the whole system of progress, as I have explained, is opposed to it. Moreover, gravel and sands are never drifted away from sea-shores, except by the very largest of rivers, like the Amazon; and with these, only part of the lightest or finest detritus is carried far away; for much the larger part is returned to the coast through tidal action, which has a propelling movement shoreward, where there are soundings. The existence of an Amazon on any such Atlantic continent in Silurian, Devonian, or Carboniferous times, is too wild an hypothesis for a moment's indulgence.

V. The bearings of the facts in American Palæontology on the science, might well occupy another full discourse. I will close with brief allusions to some points of general interest.

1. The change in the Fauna of the globe as the Age of Man approaches, is one of the most interesting facts in the earth's history. It was a change not in the types of the races, (for each continent retains its characteristics,) but a remarkable dwindling in the size of species. In North America the Buffalo became the successor to the huge Mastodon, Elephant, and the Bootherium; the small Beaver to the great Castoroides; and the existing Carnivora are all comparatively small.

Parallel with this fact, we find that in South America, as Dr. Lund observes, where, in the last age before Man, there were the giant Megatherium and Glyptodon, and other related Edentates, there are now the small Sloths, Armadillos, and Ant-eaters.

So, also, on the Oriental continent, the gigantic Lion, Tiger, Hyena, and Elephant, and other monster quadrupeds, have now their very inferior representatives.

In New Holland, too, the land of Marsupials, there are Marsupials still, but of less magnitude.

2. This American continent has contributed to science a knowledge of some of the earliest traces of Reptiles,—the species of the Pennsylvania coal formation, described by Mr. King and Mr. Lea, and others from the Nova Scotia coal-fields, discovered by Messrs. Dawson and Lyell.

It has afforded the earliest traces of birds thus far deciphered in geological history,—the colossal and smaller waders, whose tracks cover the clayey layers and sandstone of the Jurassic rocks in the Connecticut valley. The earliest Cetacea yet known are from the American Cretaceous beds, as described by Dr. Leidy. And among the large Mammals which had possession of the renewed world after the Cretaceous life had been swept away, the largest, as far as has been ascertained, lived on this continent. The Palæotheria of the Paris Basin, described by Cuvier, were but half the size of the allied Titanotheria of Nebraska.

But here our boasting ceases, for, as Agassiz has shown, the present Fauna of America is more analogous to the later Tertiary of Europe than to the existing species of that continent.

In the Palæozoic Ages, to the close of the Coal Period, the American continent was as brilliant and perhaps as profuse in its life as any other part of the world. It was a period, indeed, when the globe was in an important sense a unit, not individualized in its climates or its distribution of life, and only partially in its seas. But from this time the contrast is most striking.

The whole number of known American species of animals of the Permian, Triassic, Jurassic, Cretaceous, and Tertiary Periods is about two thousand; while in Britain and Europe, a territory even smaller, there were over twenty thousand species. In the Permian we have *none*, while Europe has over two hundred species. In the Triassic, *none;* Europe, one thousand species. In the Jurassic, (the supposed Triassic here included) sixty; Europe, over four thousand. In the Cretaceous, three hundred and fifty to four hundred; Europe, five to six thousand. In the Tertiary, hardly fifteen hundred; Europe, about eight thousand.

America, since Palæozoic times, has therefore been eminent for the poverty of its Fauna.

Again: the Mammalian Age in America, although commencing with huge Pachyderms, shows little progress afterward. The larger quadrupeds continue to be mostly herbivorous, and the Carnivora, the higher group, are few and of comparatively small size. *The Herbivora are still the typical species.* While in Europe and Asia, at the same time,—that is, in the Post-tertiary,—the Carnivora are of great size and ferocity, far exceeding the largest of modern Lions and Tigers, and they exist in immense numbers. The single species of Lion described by Dr. Leidy, from a bone from near Natchez, hardly lessens the contrast.

South America, as has been remarked by Agassiz and others, sustains the inferior position of America. The huge Sloths, Megatheria, and other Edentates of the South, are even lower in grade than the ordinary Herbivora, and place that Southern continent at an inferior level in the scale. Although there were Carnivora, they were much smaller than the European. *The Edentates are its typical species.*

The supremacy of the great Oriental continent is, therefore, most signally apparent.

The contrast is still greater with Australia and New Zealand, whose past and present Fauna and Flora have been well said by Agassiz and Owen to represent the Jurassic Period,—the present era affording Trigonias, Terebratulæ, Cestraciont Fishes, and the Araucarian Coniferæ, all Jurassic types, besides Kangaroos and Moas. Among Mammals, as is well known, *the Marsupials*, the lowest of all in the class, *are its typical species.*

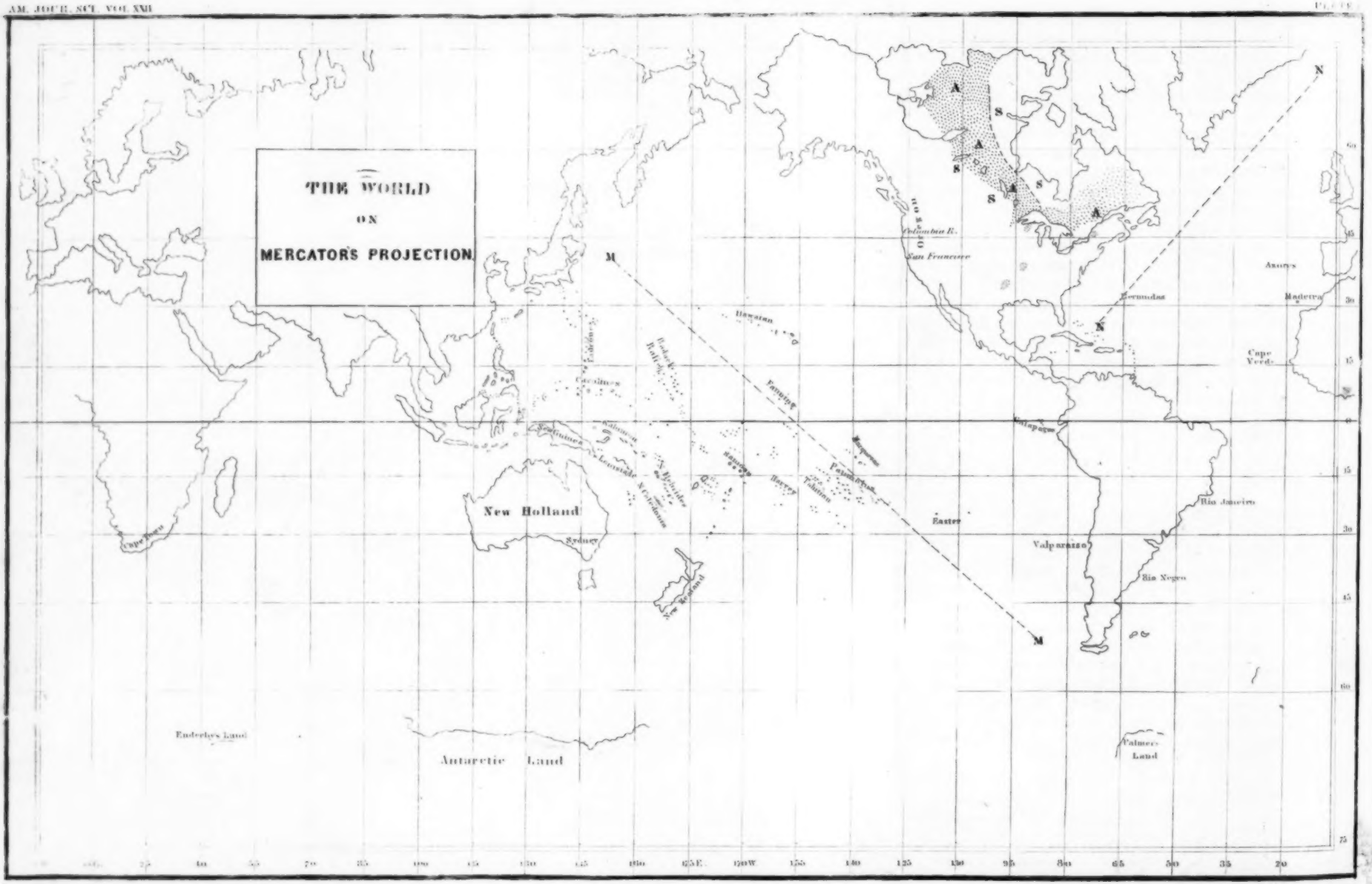
Ever since Palæozoic times, therefore, the Oriental Continent,—that is, Europe, Asia, and Africa combined,—has taken the lead in animal life. Through the Reptilian Age, Europe and Asia had species by thousands, while America was almost untenanted. In the later Mammalian Age, North America was yet in the shade, both in its Mammals and lower tribes; South America in still darker shadows; and Australia even deeper still. The earth's antipodes were like light and darkness in their zoölogical contrasts. And was there not in all this a prophetic indication, which had long been growing more and more distinct, that the Eastern Continent would be man's chosen birthplace? that the long series of living beings, which had been in slow progression through incalculable ages, would there at last attain its highest exaltation? that the stupendous system of nature would there be opened to its fullest expansion?

Another of our number has shown in eloquent language how the diversified features and productions of the Old World conspired to adapt it for the childhood and development of the race; and that, when beyond his pupilage, having accomplished his rescue from himself and the tyranny of forces around him, and broken the elements into his service, he needed to emerge from the trammels of the school-house in order to enjoy his fullest freedom of thought and action, and social union. Professor Guyot observes farther, that America, ever free, was the appointed land for this freedom and union,—of which its open plains, and oneness of structure, were a fit emblem; and that, although long without signs of progress or hope in its future, this land is to be the centre of hope and light to the world.

In view of all these arrangements, man may well feel exalted. He is the last of the grand series. At his approach, the fierce tribes of the earth drew back, and the race dwindled to one-fourth its bulk and ferocity,—the huge Mastodons, Lions, and Hyenas yielding place to other species, better fit to be his attendants, and more in harmony with the new creation. Partaking of the Divine image, all nature pays him tribute; the universe is his field of study; an eternity his future. Surely it is a high eminence on which he stands.

Yet he is only *one* of the series; one individuality in the vast system. How vain the philosophy which makes the creature the God of nature, or nature its own author! Infinitely beyond man, infinitely beyond all created things, is that Being with whom this system, and the combined systems of immensity, were as one purpose of His will.*

* This Address, exclusive of the notes, is cited from the Proceedings of the Amer. Assoc. IXth Meeting at Providence, R. I. It was delivered by the author on retiring from the duties of President.


THE WORLD
ON
MERCATOR'S PROJECTION.
New Holland
Sydney
New Zealand
Cape Town
Enderbys Land
Antarctic Land
Palmers Land
Easter
Valparaiso
Rio Janeiro
Rio Negro
Bermudas
Madeira
Azores
Cape Verd
San Francisco
Columbia R.
Hawaian
Radack
Ratlick
Pelew
Caroline
Solomon
Louisiade
Friendly
Navigators
Harvey
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ART. XXV.—*On the Plan of Development in the Geological History of North America*, with a map; by JAMES D. DANA.

ON other occasions, I have discussed at some length, the outline and surface features of the continents, the parallel courses of island groups, and the relations between the structure of the continental borders and the extent of the adjoining oceans; and I have endeavored in connection to elucidate the great principle of geological dynamics, which is at the basis of these characteristics of our globe.* I propose at this time to point out the relations between the operations of this principle or agency and the special geological history of the North American continent.

To render this application of the subject intelligible, it is necessary to review briefly the fundamental facts just alluded to. For this purpose, I would direct attention to a Mercator's Chart of the World, (see plate) on which the whole is open to examination—such a chart being a minature representation of the facts themselves, and the order observed among its parts, the syllables which spell out the principles.

In the first place, note the two great oceans, the Alantic and the Pacific—both widening south, and coalescing in a vast ring of ocean around the south pole, while narrowing north and uniting in a small arctic sea. The Indian Ocean is a third north and south ocean: but it reaches north only a little ways beyond the equator.

As the Atlantic is less than half the breadth of the Pacific, so the American continent is less than half the breadth of the great Orient, including Europe, Asia and Africa. It is seen also that while the North Atlantic treads off to the northeast, and the whole Atlantic is a zigzag channel with a main *northeast* course, the Pacific is a *northwest* channel, its longest diameter (represented by the line M M), being at right angles nearly with the trend of the Atlantic (N N). This longest diameter, moreover, corresponds with the general trend of the Pacific islands; for these islands have a nearly parallel course all through the ocean, the New Hebrides, Kingsmills, Samoan, Tahitian, Marquesas and Sandwich islands, lying in approximately parallel lines.†

* Am. Jour. Sci., [2], ii, 335, 352, iii, 94, 176, 381, iv, 88; Report, Geol. Expl. Exped., 756 pp. 4to., 1849, pp. 11, 414, 429; Proceedings Amer. Assoc. vol. ix, Providence Meeting, 1855, and page 305 of this volume.

† I may here add, what I have elsewhere explained at length, that the trends of the Pacific, while having a general correspondence of direction, pertain to two systems, one the Central Pacific, the other the Australasian. The Central Pacific begins in the Paumotu Archipelago, or rather still farther east, in Easter Island and Gomez; is thence continued on a west-northwest course, by the Society Islands, and the Hervey Islands more south; thence by the Samoan and Fakaafo groups; thence more northwesterly by the Vaitupu and Kingsmills, to the Radack and Ralick groups,

In the body of New Zealand, however, and some other parts, the transverse trend of Eastern America is represented.

Now what is the relation between the borders of the continents as to features and structure, and the extent of the oceans?

1. Look first to North America. Observe the general direction of the coast conforming to the prevalent trends of the globe, the northeast and northwest, and thus giving it its triangular form. See the low Appalachians facing the *small* Atlantic, the lofty Rocky Mountains, mostly a double line of heights, facing the *broad* Pacific, besides a second towering range, the Cascade and Sierra Nevada, nearer the sea. May we not say, *As the height of the Appalachians to the size of the Atlantic, so is the height or extent of the Rocky range to the size of the Pacific?*

In South America, there is the same relation—the low Brazilian mountains on the Atlantic side, the lofty Andes on the Pacific, and the latter exceeding the Rocky Mountains as much as the South Pacific exceeds the North Pacific; so that we may make another proportion, *As the height of the Rocky Mountains to the North Pacific, so is the height and boldness of the Andes to the South Pacific.*

In the Orient, the mountains towards the Atlantic, or those of Europe, are low and limited, compared with the long and lofty ranges of the Pacific side; and these last are inferior to the Himalayas, the sublimest heights of the world, which face the Indian ocean—a large and open ocean, while the Pacific towards Asia is much encumbered by islands.

In Africa, the loftiest and longest mountains are those of Abyssinia, on the east, facing the Indian Ocean, some of whose ridges are eleven to fourteen thousand feet in height, and one

which run nearly north-northwest; making thus a great sweeping curve, of several strands, over 6000 miles long. The Sandwich or Hawaian islands on the north side of the equator (2000 miles in whole length) is the opposite or northern side of the same system, slightly curving with the convexity to the north: while the Marquesas and the Fanning or Washington group lie along the axis of this great Central Pacific area. The other system is concentric around Australia, (New Holland). The line of new Hebrides, near northwest in course, is continued in the Salomon Islands, and New Ireland, becoming gradually east and west in the Admiralty Islands, north of New Guinea. The line of New Caledonia, another curving strand in the system, is continued in the Louisiade group and New Guinea, and becomes east and west in western New Guinea. The foot of the New Zealand boot, and the Coral Archipelago between New Caledonia and Australia accord with the system. The position of these lines concentric around Australia correspond with the idea that the position and extent of this continent, has had some influence in determining the directions.

These two systems, the Central Pacific and Australasian, though so distinct, are yet bound together in one. For while the great central range has its main course along the Kingsmills and Radack groups, it sends off at the Kingsmills, a western branch, the Carolines, which is actually parallel with the lines of the Australasian system.

The transverse trend of New Zealand, which is continued in the Friendly Islands north, is the correlate of the northwestern, the two having a mutual dependence, and together distinguishable in many groups of islands as well as in the features of the Continents.

peak near the equator is 20,000 feet. In Australia, the Australian Alps, as they are called, are on the east fronting the Pacific, here the wider of the bordering oceans.

Thus all over the world, the highest mountains stand fronting the largest and deepest oceans; and the "rule of three" statement of the fact scarcely conveys a wrong impression.

2. We observe further that the coasts are in general so turned as to face the widest range of ocean. The Appalachians with the neighboring coast do not face northeast towards the European continent, but southeast, towards the great opening of the Atlantic between America and Africa. So on the west side of North America the Pacific coast faces, not towards Asia, but southwest, where the broadest range of ocean is before it.

3. Consider now a little more closely the structure of these ocean borders. How is it as to the effects of heat or volcanic action?

In North America, on the side of the *small* ocean, the Atlantic, we find metamorphic rocks, some trap dykes, and a few tepid springs. On the side of the *great* ocean, the Pacific, all these phenomena occur, and besides, some of the grandest volcanoes of the globe, while basaltic floods have buried out of sight almost all other rocks over a considerable part of the country. Mount St. Helens, Mount Hood, Mount Shasta, and a dozen others, twelve to eighteen thousand feet high, make a majestic file of fire mountains not yet wholly extinct. May we not then say, *As the size of the Atlantic to the action of heat on the Atlantic border, so is the size of the Pacific to the action of heat on the Pacific border*?

In South America, there is a direct repetition of the same facts on a still grander scale: the Brazilian side, with metamorphic rocks and no volcanoes; the Pacific side, with volcanic heights of 20,000 feet and upward.

In the Orient, there are some small volcanic operations on the Atlantic side; but an unnumbered host down through Kamtschatka, Japan, and the islands south on the Pacific side.

In Africa, there are great volcanoes in the Red Sea and the lofty Abyssinian mountains, and only a few on the east, in the Gulf of Guinea, where, in fact, the continent opens on the Southern Ocean and not simply on the narrow Atlantic; the volcanoes are at the junction of the two lines, in or near the Bight of Biafra.

4. Again, these effects of heat are confined mostly to the region between the crest of the border mountains and the ocean, and are most intense towards the coast line. Thus the crystallization or metamorphism of Eastern North America, from Labrador to Georgia, is strongly marked towards the ocean, and diminishes going westward. So on the Pacific side: the great

volcanoes are not on the east or landward side of the crest, for there is not a volcano on that side, but on the seaward side, and not very far from the ocean. Thus we may almost say, *The nearer the water, the hotter the fire.*

5. Again, the mountains that make the borders, consist as is now well known since the surveys of the Professors Rogers, of rocks that have been pressed up out of place into a series of immense folds, like the folds we may make in paper by pressing laterally; only the rocky folds are many miles in range and of mountain height; and these folds or plications and displacements are most numerous towards the ocean, and are parallel nearly to the ocean. Hence again, *The nearer the water, the vaster the plications of the rocks.*

6. Over the interior of North America, there are not only no volcanoes, but there never have been any since the earlier Silurian, as shown by the absence of their remains among the strata; and this is so, notwithstanding the abundance of salt water over the regions in those ancient times. Over the interior of Asia there are no volcanoes, as is well known, except the three or four in the Thian-Chan Mountains. The great volcanic belt of the Orient stands out a short distance from the water-line of Asia, in the Japan range of islands, thus directly edging the oceanic basin; for the intervening region of shallow waters is properly a submerged part of the continent.

7. In contrast with this non-volcanic character of the interior of the continents, the islands of the oceans, it should be remembered, are all volcanic where not coral, and those of coral probably rest on a volcanic basis. Dhwalagiri, in the Himalayas, 28,000 feet high, is granitic; and surely we might have looked for some granitic peaks among the central islands of the oceans: but there are none.

At the same time, as others have remarked, the transverse seas which divide the Northern and Southern continents, the East Indies, the Mediteranean and West Indies, are characterized by volcanoes.

If then, the typical form of a continent is a trough or basin, the oceanic borders being raised into mountains; if these borders are so turned as to face the widest range of ocean; if the height of these border mountains and the extent of igneous action along them is directly proportioned to the size of the oceans,—the Pacific, accordingly, being girt with great volcanoes and lofty mountains, while the narrow Atlantic is bounded by smaller heights and but few volcanoes; if, moreover, volcanoes characterize the islands of mid-ocean and not the interior of the continents: What is the legitimate inference?

Most plainly, that the extent and positions of the oceanic depressions have some way determined, in a great degree, the fea-

tures of the land; that the same cause which originated the one, impressed peculiarities on the other; that the two had a parallel history through past time—the oceanic depressions tending downward, the continents upward; in other words, that they have both been in progress with mutual reaction from the beginning of the earth's refrigeration. The continents have always been the more elevated land of the crust, and the oceanic basins always basins, or the more depressed land.

We thence learn that the profounder features of the earth were marked out in the earliest beginnings of geological history, and that the whole subsequent progress has been a working on this basis. Other and more direct evidence of this fact I alluded to in my address before this Association last year—evidence derived from the extent and nature of the Potsdam sandstone, the earliest of the Silurian strata, showing that this primal rock was laid down over a large part of North America by a sea which just bathed its surface—thus proving that the continent was already made, and indicating in part its water level.

The relation between the extent of the oceans and the border features of the continents, which has been pointed out, is not simply a relation of fact, but of effect and dynamics, pointing to a unity of cause. The one cause is assuredly not in the waters of the oceans, for these are inert: they cannot bake rocks, light up volcanoes, fold the heavy strata, and make mountains. The cause is no paroxysmal force, exhausted in a temporary freak of nature. It is some profound, systematic, untiring force, which in its slow movement, has counted centuries as if seconds. The Appalachian range is one mark of its power; but not the result of a fitful heave: on the contrary, a work of time, and time so long, that the resisting strata could bend in many plications without being reduced to chaos; so long, that New England and regions south, which entered the period of catastrophe as a territory of sedimentary beds, came forth at last a region of granite, gneiss and crystalline schists. Most of the mountains of the globe, for the reasons stated, we must regard as other effects of this fundamental cause; and it is therefore no matter of surprise that they should have in general a common system of structure.

A unity of cause there must be for the great phenomena of geology. Such is nature in all her departments. Details are the means by which we penetrate to the deep-seated cause; and when that cause is once reached and fully apprehended, the details have new interest from the harmonious relations thus developed,—as the leaves and twigs of a tree derive their grandeur and the most of their beauty from the rising trunk and spreading branches to which they are subordinate, and with which they are in perfect harmony.

What then is the principle of development through which these grand results in the earth's structure and features have been

brought about? We detect a plan of progress in the developing germ; we trace out the spot which is first defined, and thence follow the evolution in different lines to the completed result: may we similarly search out the philosophy of the earth's progress?

The organizing agencies in the sphere are—

1. Chemical combination and crystallization.

2. Heat, in vaporization, fusion, and expansion, with the correlate force of contraction which has been in increasing action from the time the globe began to be a cooling globe.

3. The external physical agencies, preëminently water and the atmosphere, chiseling and moulding the surface.

4. The superadded agency of life.

Of these causes, the first is the molecular power by which the material of the crust has been prepared. The third and fourth have only worked over the exposed surface. But the second, while molecular in origin, is mechanical in action, and in the way of contraction, especially, it has engaged the universal sphere, causing a shrinkage of its vast sides, a heaving and sinking in world-wide movements. Its action therefore, has been coextensive with the earth's surface throughout the earth's history. If a power at all, it has been a dominant power in the great changes, and in connection with the profound structure of the crust received through consolidation, it has wrought out the earth's lineaments, varying them with her years from the first featureless sphere to the bold expressiveness and wrinkles of age. This is the cause that most concerns us at this time.

There must be system in the intimate structure of the crust. For if it was once fluid, and is now one or two scores of miles thick, all this thickness beyond that of the first film has been produced through gradual, exceedingly gradual and prolonged cooling, adding, by downward increase, to the solid surface arch: and if ice over a pond when thickening in this same way by additions downward to the surface film takes a crystalline texture perpendicular to this film, as has been proved, we may safely infer that the crystallization of the earth's crust as it slowly thickened would have taken a regular structure, and the more surely since we know that the mineral feldspar, which gives a cleavage structure to granite, is the prevailing mineral in all igneous rocks. Thus we approach some explanation of the prevalence of two great systems of trends in the features of the globe. But this subject we pass by, to the one which more immediately concerns us—the surface features of the continents.

The contraction to which I have alluded, going on after a crust was formed over the earth, would necessarily fracture, displace, or wrinkle the crust, as the same cause, contraction, wrinkles a drying apple. The large rind is more than sufficient for the contracted sphere; and the drawing downward of some parts

must cause the bulging of others. If any large areas of the crust were sinking more than the rest, this very subsidence would necessarily push up the borders of these areas into angular elevations or folds; and it follows necessarily,—the larger these areas the higher the border elevations.

These are the simple principles. The oceanic basins are these areas of greatest subsidence; and hence would necessarily flow the law, already established as a matter of fact—the larger the ocean, the higher the mountains on its borders, the deeper the fractures and displacements there, and the vaster the outflow of internal heat and lavas. The size, therefore, of the oceans, that is, their extent and depth, is relatively a measure of the force exerted on their sides.

The wrinkles or elevations on the globe seem large when man measures them by comparison with his own stature. But a section of the land, true to nature, corrects this misapprehension. In a section of the North American continent, drawn to a scale twelve feet long, one-ninth of an inch will stand for an altitude of 10,000 feet; one-sixteenth of an inch for the White Mountains, and about three-tenths for the Himalayas.

After this review of principles, let us now turn our attention to North America and seek out its plan of development.

I. The triangular form of the continent has been noted and its simple ocean boundary: and it should be observed that the continent is set quite to the west of South America, so as to possess this simplicity of boundary and therefore of moulding forces in its highest perfection.* The small Atlantic on one side, and the great Pacific on the other, indicate approximately the relative amounts of force from the two directions, the southeast and southwest, during the progressive ages of the history;—that to the eastward the power was comparatively moderate, gently folding up the Appalachians, and to the westward it was strong and mighty, even to the raising of the Rocky range and opening the great volcanoes of Oregon. We thus learn, with a degree of precision not to have been anticipated, the direction and efficiency of the great organizing forces.

Glance now at American geological history from this point of view, and consider where was the first germinant spot of the growing continent, and what was thence onward the course of development under the influence of this agency.

The earliest spot or primal area will be that of the Azoic rocks, the first in the geological series. Such an area (see Chart, A A A) extends from Northern New York and Canada, north-west to the Arctic Ocean, lying between the line of small lakes (Slave, Winnipeg, &c.) and Hudson Bay. East and west, it dips under

* The contrast with Europe in this respect is striking, and accounts, as I have said, (Address, &c., p. 311,) for the greater simplicity of North American Geology.

Silurian strata (S S;) but it is itself free from superincumbent beds, and therefore, even in the Silurian age, it must have been above the ocean. And ever since, although subject, like the rest of the world, to great oscillations, it has apparently held its place with wonderful stability, for it is now, as probably then, not far above the ocean's level.

This area is central to the continent; and, what is of prominent interest, it lies parallel to the Rocky Mountains and the Pacific border, thus proving that the greater force came from that direction in Azoic times, as well as when the Rocky Mountains were raised. Thus this first land, the germ or nucleus of the future continent, bears in itself evidence with respect to the direction and strength of the forces at work. The force coming from the Atlantic direction has left comparatively small traces of its action at that time. Yet it has made its mark in the Azoic stretching through Canada to Labrador, in the dip and strike of the New York Azoic rocks, in the direction of the channel of the St. Lawrence and the northwest coast of Lake Superior, and probably also in the triangular form of Hudson's Bay. Against this primal area, as a stand-point, the uplifting agency operated, acting from the two directions, the Atlantic and the Pacific; and the evolution of the continent took place through the consequent vibrations of the crust, and the additions to this area thereby resulting; the ocean in the meantime pursuing its appointed functions in the plan of development, by wearing exposed rocks and strewing the shores and submerged surface with sand, gravel or clay, or else growing shells, corals and crinoids, and thus storing up the material of strata and burying the life of successive epochs.

These long secular vibrations, movements by the age rather than day, dipping the surface and raising it again in many and varying successions, were absolutely essential to the progress. Had the continent been stable, there could have been no history, no recorded events of changing life and alternating deposits: all would have been only a blank past. These forces, therefore, working mainly from the southeast and southwest, were actually organizing forces, essential to the completion of the continent,—to the production of its alternations of limestones, shales, sandstones and conglomerates, and its sweeping catastrophes burying the old preparatory for higher forms of life:—the continent in the course of these movements, being at one time, it may be, just beneath the ocean's surface, and having beds of sand and gravel accumulating under the action of the waves; then in somewhat deeper and clearer waters, with limestones forming from coral or crinoidal plantations or the growth of shells; then, perhaps, rising from the waves, bringing death upon its sea tribes in one universal desolation; then, sinking slowly in the waters

again, and varying in its accumulations from sandstones to shales, pebble beds or limestones, with the depth and the currents; and then again above the tides, although destruction to all the life of the ocean was in the movement; and, perchance, lying in the open air for an era, to receive the mists and rains and sunshine, and become luxuriant through new creations with broader prairies than now cover the West. Alternations like these were again and again repeated, as geology has shown.

Through these means, the continent, which was begun at the far North, a region then tropical but afterwards to become inhospitable, gradually expanded southward, area after area as time moved on being added to the dry land.

First, as the facts show, the Silurian deposits of Canada and the North, adjoining the Azoic, were left above the sea, for these rocks there are not overlaid by later beds; and, therefore, were not the sea-bottom of later seas. Next, the adjacent Devonian were added to the main land as far south as Southern New York and around by the west; for, as the New York geologists have shown, the carboniferous beds which come next do not reach into that State. By the time of the Jurassic period, the continent had expanded much farther to the southward, for the carboniferous rocks over the land were out of water, their beds having already been folded up and elevated in the Appalachians. The red sandstone of the Connecticut Valley and of the Atlantic States from New York to Alabama leave little doubt as to the water line of that era. In the Cretaceous period the continent had farther expanded along the Atlantic; but in the Mississippi Valley the Mexican Gulf still extended north even to the head waters of the Missouri. Next, as the Tertiary opened, the continent had yet more widely enlarged its bounds, south and southeast; and if the waters of the Mexican Gulf for a while claimed a place over some part of the Nebraska plains, as late observations suggest, by the close of the period the continent in this direction had nearly reached its full maturity. These steps of progress are indelibly marked in the position, and obvious seacoast, off-shore or estuary origin of the Jurassic, Cretaceous and Tertiary beds of the country.

Passing towards the Pacific, we find evidence in the carboniferous limestone that the Rocky Mountains were mostly under shallow water as the Carboniferous age opened, the mountains themselves unborn. Later in the Cretaceous and Tertiary periods, as the rocks towards the coast testify, the continent had extended far to the southwest, and was nearly complete in that direction, as well as to the south and southeast.

Thus the enlargement went on to the southward, each period making some addition to the main land, as each year gives a layer of wood to the tree. Not that this addition was free from

oscillations, causing submergences, for these continued long to occur; but the gain, on the whole, was a gain—a progress; and the moving ages made the accession a sure and permanent gain as the continent became more stable.

II. But in the statement that the growth of the continent was to the south, southeast, and southwest, we assert only the most general truth respecting it. The continent has its special features as much as any being of organic growth, and the elimination of these features is to be traced to the same system of forces. The Appalachian range on the east, the Rocky Mountains and the subordinate chains on the west, the lower lands and lakes of the interior, all in systematic relation, are the more marked of these features; and the vast river systems, with the broad alluvial flats and terraced plains, the wide spread drift, the denuded heights and channeled slopes and lowlands, are subordinate peculiarities of the face of the continent.

The Appalachian range of heights, as I explained a year since, was commenced in the Silurian age, and even earlier long before a trace of the mountains had appeared.* The force from the southeast, in the dawn of the Palæozoic era, had made the Appalachian region generally shallower than the Mississippi valley beyond. The vast sandstone and shale deposits of the region bear marks in many parts of sea-shore action, while the limestones which were forming cotemporaneously farther west, indicate clearer and somewhat deeper seas; and the patch of Azoic in northern New York, lying at the northern extremity of part of the range, points to an anterior stage in the same course of history; so that, in early time, long before there were mountains, the future of the continent, its low centre and high borders, was foreshadowed. We can hardly doubt that the region of the Rocky Mountains was in the same condition, in the main, with that of the Appalachians. Moreover, these borders, or at least the eastern, for ages anterior to the making of the mountains, were subject to vastly greater oscillations than the interior; for the Silurian and Devonian sandstones that occur along from New York to Alabama are of great thickness, being five times as thick as the limestones and associated deposits of the same age to the west. A limestone bed, moreover, is of itself evidence of comparatively little oscillation of level during its progress.

We hence learn that in the evolution of the continental germ, after the appearance of the Azoic nucleus, there were two prominent lines of development; one along the Appalachian region, the other along the Rocky Mountain region—one, therefore, parallel with either ocean. Landward, beyond each of these developing areas, there was a great trough or channel of deeper ocean waters, separating either from the Azoic area.

* Address &c.—See this volume, page 319.

The Azoic, as has been indicated, has something of a V shape, (or ∨), with Hudson Bay between its arms. This succeeding step of progress is the partial development of a larger V outside of and parallel to the Azoic nucleus. The channels alluded to lie between the two V's. The bar of the outer V on the left is of great breadth and made up of several broad parallel bands or ranges of elevations; that on the right is quite narrow comparatively, yet also etched in several parallel lines.

The Mexican Gulf is all that remains of the larger of these channels. Its waters once stretched to the Arctic Sea, and were in early time but the deeper part of the continental ocean. Later, as the ages moved on, there was land to the north, and a line of freshwater lakes along its former course; and the Gulf reached no higher than the headwaters of the Missouri. Later still, and its limits became more contracted, till now the full-grown continent has but her foot in the salt water.

The Gulf of St. Lawrence marks the outlet of the other channel, and the River St. Lawrence its course. The great lakes, as well as the smaller lakes north, lie near the limits of the Azoic nucleus within these ancient troughs or depressions; and the largest lake, Lake Superior, is at the junction of the two lines.

Such was the law of growth. The molecular forces *beneath* the continent, from the progressive cooling there going on, were not idle, and must have modified the results. But the main action causing the lifting and sinking of the crust and the final gain to the land, proceeded from the directions of the oceans. The inequality in the forces from the two directions, as well as in the form and depth of each oceanic or subsiding area whence the forces mainly came, would necessarily have produced many irregularities in the results, as I have remarked in another place,* and will not now dwell upon.

The Pacific region has always been true to its own grandeur. The force from that direction not only made the Rocky Mountains to rise and a file of lofty volcanoes to light up its waters, (while the most the gentler Atlantic could accomplish was a bending up of the strata into Appalachians, and a baking of some of the beds,) but it also added tenfold the most dry land to the continent; and even after the tertiary rocks were deposited, it elevated the continental border at least two or three thousand feet—ten times beyond what happened on the Atlantic side.†

* Amer. Jour. Sci. [2], vol. iii.

† Whatever doubts may exist as to the cause, there can be none as to the actuality of the force on the two sides, the Atlantic and the Pacific. The elevation of the mountains on each border is proof beyond question; and their relative extent and height is evidence indubitable as to the relative amounts of force exerted. The parallel *folds* on the Atlantic side show that there it *was actually lateral* force from the southeast; and the several parallel ranges on the Pacific side, parallel to the

But look further, and consider that the great lines of elevation on the Pacific side are parallel nearly to the islands of the ocean; that these islands are like a long train stretching off from Asia to the east-southeast; that New Hebrides, New Caledonia in the southwest, with the foot of the New Zealand boot and northwestern Australia, conform to the general parallelism; and it will then be comprehended that we have been considering not simply a continental system of progress, but one involving the whole globe. It appears also from the history of the coral islands of the Pacific, that while the Tertiary and Post-tertiary elevations were going forward on the Pacific border of North America, a slow and gradual subsidence was in progress over a parallel region across the middle of the ocean. The axis line of the Pacific is not only the main trend of its lands, but is also nearly the course of the great subsidence which is indicated by the history of the coral islands.*

III. I have said that these two systems of forces—the southeast and southwest—continued to act through the Tertiary period, working out the continent, and bringing it nearly to its adult extent. At the meeting of this Association at Providence I pointed out the fact that at the close of the Tertiary there was a change in the movement; that during the following period, the Post-tertiary, there were high-latitude oscillations; and I endeavored to show, that there was first an elevation of the continent over the north for the first or glacial epoch; then a subsidence (as shown by the seashore deposits on Lake Champlain, and the highest terrace of the lakes and rivers) during a second or Laurentian epoch; and finally, an elevation to its present height, for the third or Terrace epoch. Whether the elevation for the Drift epoch be admitted or not, all agree that the oscillation attending it was a northern phenomenon. These several changes thus affected mainly the latitudes north of the middle of the temperate zone, or were but slightly felt to the south of this. It is a remarkable fact that the coasts of the Arctic regions, which have now been rather widely explored, have not presented any Jurassic, Cretaceous or Tertiary deposits, and there is, therefore, no evidence of their

ocean, are proofs of similar lateral action there, but from the southwest. Then the dominance of these two trends in the uplifts over the whole continent in its oldest and newest regions and rocks, are like the warp and woof of a fabric, determined by the organizing forces themselves of the structure.

* Amer. Jour. Sci. vol. xlv, (1843) 131, and [2], iii, 396, (1847).

One consequence of these facts and principles may be here alluded to.—If the position of the Atlantic and Pacific has determined the main directions of the organizing forces through all time, and if, owing to the direction, as the facts show, elevations having the *same* strike or trend have been formed in successive geological ages, it is evident that the elevation theory of mountains, sustained by Elie de Beaumont, must be received with much hesitation. One dial-plate for the world, such as he has deduced mainly from European geology, is a splendid hypothesis; but it may not mark time for America or the other continents.

having been in those eras under water. Such beds may hereafter be detected; but the great fact will still remain, that they are there of limited extent, if not wholly absent. As far as known, there is no Tertiary on the coasts north of Cape Cod. All development or growth there seems to have ceased, or nearly so, with the Palæozoic era or the close of the Carboniferous age. But there are Post-tertiary deposits in the Arctic regions in many places, situated hundreds of feet above the sea, containing shells of existing Arctic species. This alone, independent of other evidence, would prove a change in the conditions of geological progress after the Tertiary period. The necessary inference is, then, that as long as the southwest and southeast forces were in active play, and the extremities of the continent were thereby in process of growth, there was little change going on in the far north. But when the continent was nearly finished, its extremities grown, and the stability consequent upon adult age acquired, then, through a series of oscillations, a course of development was carried on in the more northern regions, giving a final completion to the continent—an action, which, as I have elsewhere explained, involved the higher latitudes about the whole sphere, north and south of the equator.*

We shall understand more definitely the relations of the later to the older oscillations, if we consider that all were due to one grand cause, influencing the whole extent of the continent even to the Arctic ocean; that the force from the north, the southeast, and the southwest, according to the principle explained, was proportioned approximately to the sizes of the oceans, the Arctic, the Atlantic and the Pacific; that the greater forces from the southeast and southwest acted against that from the north, and through their superior strength or the concurrent greater flexibility of the crust, kept up those vibrations in the progress of which the border mountains were made; but at last, the southeast and southwest action almost ceasing through the stiffening and uplifting of the crust, then the northern force, having a stable fulcrum, made itself felt in the long and slow oscillations of the Post-tertiary. Under this mode of view it will be seen that all was part of one system of development.

If we rightly apprehend the results of the Post-tertiary period, we shall perceive that there was vast importance in these finishing operations over the sphere:—that during its progressing centuries, the great phenomena of the drift took place, covering hills and plains with earth; that the valleys for our rivers were then either made or vastly enlarged; that immense alluvial plains were spread out in terraces over the interior and in flats along the shores; that thus a large part of the brighter fea-

* Address, etc., this volume, p. 327.

tures of the globe were educed. The mountains of the earth at last stood at their full altitude, having gained some thousands of feet since the Tertiary; and rivers, true offspring of the mountains, taking their size from the size of the mountain ranges, were sent on renovating missions over the breadth of the continents. Indeed, the upper terraces of the rivers show that during the Post-tertiary, these interior waters had an extent and power vastly beyond what the streams now exhibit;—an extent which is yet unexplained, unless attributable, as I have suggested, to the declining snows of a glacier epoch. In their strength, they deeply channeled the hills, and wrought out much of the existing sublimity of mountain architecture. There was the elimination of beauty and of immediate utility in every stroke of those later waters, in striking contrast with the earlier operations of rock-making and mountain-lifting; for those very conditions, those special surface details, were developed, that were most essential to the pastoral and agricultural pursuits with which man was to commence his own development, while that grandeur was impressed on the earth that should tend to raise his soul above its surface.

This transfer of the process of development from the extremities to the more northern regions, thence evolving these new and more refined qualities of inorganic nature and humanizing the earth, has a parallel in organic growth; for the extremities are finished and adult size attained before the head and inner being are fully perfected. The analogy is fanciful; yet it is too obvious a parallelism to be left unsaid on that account.*

* I have alluded on a former page to an analogy between the progress of the earth and that of a germ. In this, there is nothing fanciful; for there is a general law, as is now known, at the basis of all development, which is strikingly exhibited even in the earth's physical progress. The law, as it has been recognized, is simply this :—Unity evolving multiplicity of parts through successive individualizations proceeding from the more fundamental onward.

The earth in igneous fusion, had no more distinction of parts than a germ. Afterwards, the continents, while still beneath the waters, began to take shape. Then, as the seas deepened, the first dry land appeared, low, barren, and lifeless. Under slow intestine movements and the concurrent action of the enveloping waters, the dry land expanded, strata formed, and as these processes went on, mountains by degrees rose, each in its appointed place. Finally in the last stage of the development, the Alps and Pyrenees and other heights received their majestic dimensions and the continents were finished out to their very borders.

Again, as to the history of fresh waters.—The first waters were all salt, and the oceans one, the waters sweeping around the sphere in an almost unbroken tide. Fresh waters left their mark only in a rain-drop impression. Then the rising lands commenced to mark out the great seas, and the incipient continents were at times spread with fresh-water marshes into which rills were flowing from the slopes around. As the mountains enlarged, the rills changed to rivers, till at last the rivers also were of majestic extent, and the continents were throughout active with the busy streams, at work channeling mountains, spreading out plains, opening lines of communication, and distributing good every where.

Again, the first climates were all tropical. But when mountains and streams were attaining their growth, a diversity of climate, (essential to the full strength of

Thus, then, the continent was completed. Contraction was the power, under Divine direction, which led to the oscillations of the crust, the varied successions in the strata, and the exuviations of the earth's life, era after era. Acting from the Atlantic and Pacific directions, it caused the southern prolongation of the growing land from the icy North to the tropics, while it raised mountains on the borders, and helped to spread the interior with plains, varied slopes, and lakes. And, finally, through its action over the north, the surface received its last touches, fitting it for a new age—the Age of Mind.

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ART. XXVI.—*Re-determination of the Atomic Weight of Lithium;* by J. W. MALLET, Ph.D.; Professor of Chemistry, Univ. of Alabama.

LITHIUM is one of the elements whose atomic weight has been several times made the subject of investigation by different chemists, and yet on examining the results of their labors we find that but one or two experiments free from serious objection are recorded, from which the received equivalent number of the metal has been calculated; and even in these experiments the method pursued has not, I believe, been such as to ensure the closest approximation to the truth. Yet the formulæ of the salts of lithia, and of minerals containing this alkali, would be seriously affected by any considerable error as regards the equivalent number assumed, since this is one of the very lowest to be found in the whole list of elements—the lowest among the metals, with the single exception of glucinum. The fact that Lithium does possess so small an atomic weight—a fact which is said to have led to the discovery of the metal by Arfwedson—is in itself very remarkable when we remember the much higher numbers by which the other alkaline metals, potassium and sodium, are represented; and it gives additional interest to accurate experiments made for the purpose of fixing the number with precision.

The following historical notice of what has been already done in this direction I have taken from a valuable little work by

the latter,) was gradually evolved, until winter had settled about the poles as well as the earth's loftier summits, leaving only a limited zone,—and that with many variations,—to perpetual summer.

The organic history of the earth, from its primal simplicity to the final diversity, is well known to exemplify in many ways the same great principle.

Thus the Earth's features and functions were successively individualized:—first, the more fundamental qualities being evolved, and finally those myriad details in which its special characteristics, its magnificent perfection, and its great purpose of existence and fitness for duty, largely consist.

A. C. Oudemans, Jr., published at Leyden in 1853,* which reviews the determination of the equivalents of twenty-two of the elements, chiefly those of the alkaline and earthy metals. The original memoirs I have for the most part been unable to consult; but the work of M. Oudemans supplies all necessary details of the experiments, and contains also judicious critical remarks upon the trustworthiness of the results.

In 1817 Arfwedson† discovered lithium, and in the course of his examination of the new element he obtained the following results from which to calculate its atomic weight.

(1.) 5·732 grm. of $LiO,SO_3$, prepared by dissolving carbonate of lithia in sulphuric acid, gave 11·454 grm. of $BaO,SO_3$.

(2.) ·597 grm. of $LiO,SO_3$ appeared to consist of ·406 grm. of $SO_3$ and ·191 grm. of LiO.

(3.) 4·204 grm. of chlorid of lithium gave 13·224 grm. of chorid of silver.

Soon after, Vauquelin‡ analyzed anhydrous sulphate of lithia, and found ·430 grm. of $LiO,SO_3$ to yield ·875 grm. of $BaO,SO_3$.

C. G. Gmelin§ found a little later that ·481 grm. of $LiO,SO_3$, precipitated by acetate of baryta, gave ·953 grm. of $BaO,SO_3$; and that the acetate of lithia produced in this experiment left on ignition ·316 grm. of carbonate.

Stromeyer‖ also analyzed sulphate of lithia, and stated its composition as

| | |
|---|---|
| Lithia, - - - - - | 30·819 |
| Sulphuric acid, - - | 69·181 |
| | 100· |

In 1828 Kralovanszky¶ published some experiments on the equivalent of lithium, in which experiments, as in those of preceding chemists, the precipitation of a solution of sulphate of lithia by acetate of baryta was the method employed. In one analysis 2· grm. of neutral, strongly ignited $LiO,SO_3$, gave 3·985 grm. of $BaO,SO_3$; and a second analysis yielded a result from which a slightly higher atomic weight was deducible.

Hermann** was the next chemist who occupied himself with the equivalent of Lithium. He prepared carbonate of lithia by precipitating a strong solution of chlorid of lithium with carbonate of ammonia or of soda, washing and igniting the precipitate. A weighed quantity of this carbonate was then brought

* Historisch-Kritisch Overzigt van de bepaling der Æquivalent-gewigten van twee en twintig metalen door A. C. Oudemans, Jr.—Leiden 1853.

† Afh. i Kemi, Fysik och Mineralogie, vi. Schweig. Journ. xxii, 93–100. Ann. de Chim. et de Phys. [2], x, 82. Pogg. Ann. viii, 189.

‡ Ann. de Chim. et de Phys. [2], vii, 287. § Gilbert's Ann. lix, 238.

‖ Stromeyer, Untersuchungen i. 435. Schweig. Journ. xxxiii. 373.

¶ Schweig. Jour. liv, 234. Berz. Jahresb. ix. 93.

** Pogg. Ann. xv, 480. Berz. Jahresb. x. 96.

in contact with muriatic acid in a gas cylinder filled with mercury, and the carbonic acid evolved was measured. It was found in one experiment =60·98, and in another =61·00 per cent of the carbonate of lithia. Hermann also dissolved this carbonate in sulphuric acid, evaporated to crystallization, and dried the crystals of sulphate of lithia over a spirit-lamp. 100 parts of the dry salt gave an amount of sulphate of baryta corresponding to 74 parts of sulphuric acid.

In 1831 Berzelius* repeated the experiments of Hermann, and with the following results. 4·4545 grm. of fused carbonate of lithia dissolved in sulphuric acid gave 6·653 grm. of sulphate of lithia; and 1·874 grm. of this anhydrous sulphate gave 3·9985 grm. of sulphate of baryta.

In 1839 Hagen† reëxamined with accuracy some of the minerals containing lithia, and discovered that this alkali occurred in them, not pure, as it had been previously supposed, but accompanied by soda; and as in the preparation of lithia salts for analysis most of the earlier chemists had taken no steps for the separation of the soda, it became obvious that most of the determinations which had been made of the equivalent of lithium were necessarily quite erroneous; and that the results of Berzelius and Hermann alone deserved any confidence, the salts analyzed by them having been prepared from precipitated carbonate of lithia.‡

Hagen himself found that 1·002 grm. of pure sulphate of lithia in crystals left on being strongly heated ·852 grm. of the anhydrous sulphate, and being redissolved and precipitated with a salt of baryta gave 1·8195 grm. of sulphate of baryta.

The above are the results of the experiments which have been made up to the present time. I have not given along with each the equivalent number deduced by the analyst himself, but have preferred to make the calculation in each case, using the most recently determined equivalents for the other substances involved in the several processes,§ and I here present the results in tabular form—

* Pogg. Ann. xvii, 379. Berz. Jahresb. x, 96.

† Pogg. Ann. xlviii. 361.

‡ It is true that Arfwedson prepared his sulphate of lithia by dissolving the carbonate in sulphuric acid; but this carbonate seems to have been obtained by precipitating the sulphate of lithia (containing soda) with acetate of baryta, filtering, evaporating the filtrate, and igniting—a process which of course would not remove the soda.

§ The equivalents used are—

| | | |
|---|---|---|
| Oxygen, | 100· | |
| Chlorine, | 443·28 | (Marignac). |
| Sulphur, | 200· | |
| Carbon, | 75· | |
| Silver, | 1349·66 | (Marignac). |
| Barium, | 857·32 | (Marignac). |

| Authority. | Salt analyzed. | At. Weight of Li. |
|---|---|---|
| Arfwedson 1st experiment, | Sulphate. | 129·30 |
| " 2nd " | " | 135·22 |
| " 3rd " | Chlorid. | 126·71 |
| Vauquelin, | Sulphate. | 116·17 |
| Gmelin 1st " | " | 135·54 |
| " 2nd " | Sulphate conv. into Carbonate. | 108·22 |
| Stromeyer, | Sulphate. | 122·74 |
| Kralovanszky, | " | 131·40 |
| Hermann 1st " | Carbonate. | 75·97 |
| 2nd " | Sulphate. | 75·82 |
| 3rd " | " | 75·67 |
| Berzelius 1st " | Carbonate conv. into Sulphate. | 80·89 |
| " 2nd " | Sulphate. | 83·01 |
| Hagen, | " | 82·41 |

Of these sufficiently discrepant numbers, those of Arfwedson, Vauquelin, Gmelin, Stromeyer, and Kralovanszky are at once to be rejected, for the reason already mentioned, that the substance analyzed by each of these chemists was not in reality a pure salt of lithia, but a mixture of salts of lithia and soda. The determination by Hermann of the amount of carbonic acid in the carbonate was not conducted in a manner likely to yield the most accurate results, and probably the same objection may be made against Berzelius's first experiment, which was made with the same salt.

We find then but three numbers apparently deserving of much confidence, namely those deduced from the analysis of anhydrous sulphate of lithia by Hermann, Berzelius, and Hagen—one experiment by each of these chemists. Hermann's result differs very considerably from the other two, and, as is observed by M. Oudemans, should have less importance attached to it, since the original weighings are not recorded, but merely the per-centage of sulphuric acid deduced therefrom by the analyst. Berzelius's result has been generally taken of late years as the true one, and with it that of Hagen agrees pretty well.

We have thus the atomic weight of Lithium as the result of but two experiments, agreeing, it is true, fairly with each other, but both made by the same process—the precipitation of sulphate of lithia by a salt of baryta, washing, igniting, and weighing the $BaO,SO_3$ produced. And as it is well known that sulphate of baryta is washed with extreme difficulty, an excess of the barytic salt used for precipitation obstinately adhering to the precipitate even after a very large quantity of hot water has been filtered through it—this fact rendering the exact determination of the sulphuric acid difficult; and as the quantity of sulphate of lithia submitted to analysis in each of these experiments was but small, and therefore the effect of any trifling error in the estimation of the sulphuric acid would be more seriously felt—it seemed that the equivalent of the metal might be redetermined

with advantage, using a larger amount of a carefully prepared salt, better adapted to the purpose than the sulphate, and requiring the process of analysis to be varied. The salt chosen was the chlorid of lithium, and I shall describe first the mode of its preparation, and then the experiments which have been made upon its composition.

Crystallized spodumene from the granite of Goshen (Mass.), where the mineral occurs with blue tourmaline, beryl, and rose mica, was finely pulverized, and 1 part mixed with 3 or 4 of unslaked lime and about three-fourths of sal-ammoniac. The mixture was heated in large crucibles to the highest temperature of a good wind-furnace. This is the process proposed by Prof. J. L. Smith* for the analysis of silicates, except that he uses carbonate of lime instead of the caustic earth. The nearly fused mass was pulverized, mixed with water, and treated with sulphuric acid in excess. The solution was filtered off from the sulphate of lime and other insoluble matter, and the latter washed with plenty of water upon a cloth filter. The still milky liquid was boiled down to a moderate bulk, and precipitated with chlorid of barium; the sulphate of baryta thrown down was washed by decantation, and the solution was filtered through paper. The filtrate was now a solution of chlorid of lithium, free from sulphuric acid, but containing the chlorids of several other metals in admixture. It was carefully evaporated to dryness to get rid of any silicic acid, re-dissolved, precipitated with ammonia, sulphuret of ammonium, and carbonate of ammonia, filtered, evaporated to dryness, and the residue heated until all ammoniacal salts were expelled. The residue was then re-dissolved, the solution boiled with a little pure milk of lime, and filtered from magnesia. The lime in the filtrate was removed by oxalate of ammonia, and the solution was evaporated to dryness, and heated to expel salts of ammonia. The residue, now containing only the alkaline chlorids, was moistened with a little water and again dried at a gentle heat, not over 100° C. The dry mass was introduced into a glass-stoppered bottle, and a mixture of equal volumes of ether and absolute alcohol was poured upon it—solution of the chlorid of lithium being aided by shaking the bottle from time to time. After a few hours the clear liquid was decanted, and the alcohol and ether were distilled off. The dry residue left by the distillation of this first alcoholic solution was again treated with ether and alcohol, the liquid again decanted and distilled, and finally the same process of purification was repeated a third time, nothing being now left undissolved by the ether-alcohol. The pure chlorid of lithium

* Amer. Jour. of Science, [2], xv, 234; xvi, 53.

was fused in a covered platinum crucible, poured out upon a sheet of platinum, and the fused mass broken up while warm, and quickly enclosed in a bottle with a well ground stopper.

This anhydrous chlorid of lithium was beautifully clear and colorless, and a portion of it taken for careful qualitative examination appeared to be perfectly pure—it was at least completely free from any traces of the earths or heavy metallic oxyds, and might be fairly supposed to have been also freed from all chlorid of sodium or potassium by the repeated treatment with ether and absolute alcohol.

On fusion in an uncovered vessel for some time the salt loses a little chlorine, and takes up oxygen, so that when redissolved in water it reacts alkaline to test-paper; but it was found that this change could be completely avoided by mixing a little pure sal-ammoniac with the chlorid of lithium before evaporation to dryness, and fusing the dry mass in a covered crucible. The heat applied must not be too great until the sal-ammoniac has been driven off,—as in a first experiment, in which the quantity of $NH_4Cl$ was considerable and the heat rapidly applied, the greater part of the chlorid of lithium was volatilized and lost, although the platinum crucible was covered and was not raised to more than a low red heat.

Having got then pure fused chlorid of lithium, it remained to determine its composition or the per-centage of chlorine which it contains. The salt is a deliquescent one, and it seemed doubtful at first whether the absorption of moisture could be prevented during weighing, but it was found that in a platinum crucible provided with a tightly fitted cover, the portion taken for analysis, consisting of but three or four fragments of the fused cake, could be weighed with ease and certainty; the weight remaining constant for more than five minutes in the hot dry atmosphere of a summer day. The balance used was an excellent one of Berlin make, permitting of accurate weighing to the one-tenth of a milligramme. Both it and the weights used were subjected to a careful examination as to adjustment beforehand.

Three or four pieces of the fused chlorid of lithium were placed in the platinum crucible used for weighing, the cover was put on, and then the vessel was heated for some time to a temperature not much below the fusing point of the salt. The crucible was cooled over oil of vitriol, weighed, reheated, again cooled, and a second time placed upon the balance, so as to observe perfect correspondence between the two weighings. The fragments of chlorid of lithium were then placed in a beaker of convenient size, and dissolved in water, while the crucible was once more heated, cooled, and weighed; its weight now being subtracted from the former weighing gave the amount of Li Cl used. The solution of Li Cl was precipitated by a slight

excess of nitrate of silver, the solution gently heated to condense the precipitate, and the latter washed with very dilute nitric acid and then with pure water, first by decantation, and afterwards upon a filter through which all the decanted liquid had been passed. When perfectly washed, the filter with chlorid of silver was carefully dried, and the chlorid of silver transferred as a single lump to a counterpoised porcelain crucible, upon the lid of which the filter was burned, the ashes being moistened with nitric and then with hydrochloric acid. The lid was placed upon the crucible, the latter was heated until the chlorid of silver began to fuse, and was then cooled over oil of vitriol, and weighed.

Two experiments made by the above method gave the following results:—

(1.) 7·1885 grm. of Li Cl gave 24·3086 grm. of Ag Cl.
(2.) 8·5947 grm. of Li Cl gave 29·0621 grm. of Ag Cl.

Now—

24·3086 : 7·1885 : : 1792·94 (equiv. of Ag Cl) : $x$
$x$ = 530·21 (equiv. of Li Cl).
530·21 − 443·28 (equiv. of Cl) = 86·93 = equiv. of Li and
29·0621 : 8·5947 : : 1792·94 : $x$
$x$ = 530·24
530·24 − 443·28 = 86·96 = equiv. of Li,

the two numbers thus obtained for Lithium agreeing with remarkable closeness.

The difference between these numbers and those of Berzelius and Hagen is however considerable; and as it seemed possible that a little chlorid of sodium still retained in spite of the purification by ether-alcohol might be the cause of this difference, I resolved to precipitate a solution of this supposed pure chlorid of lithium with carbonate of ammonia, to redissolve the carefully washed carbonate of lithia in hydrochloric acid, and, again evaporating to dryness and fusing, to redetermine the chlorine by a slightly different method—namely, that of analysis by measure, as applied by Pelouze to the examination of the atomic weights of sodium and barium.

3·9942 grm. of the chlorid of lithium thus prepared from the carbonate were dissolved in water. 10·1278 grm. of chemically pure silver (the quantity necessary for the precipitation of the chlorine, if Li = 89·, and therefore not quite sufficient for the amount of Cl actually present) were dissolved in pure nitric acid, and the two solutions were mixed in a white glass flask. The mixture was gently heated, and shaken until the chlorid of silver had completely separated, leaving the fluid clear. A solution of 1 grm. of pure silver in nitric acid had been prepared, and diluted until the volume = 1000 cubic centimeters; 1 c. c. therefore containing ·001 grm. of silver. This solution was now

cautiously added to the fluid in the flask from a pipette furnished with a small glass stop-cock and graduated to the one-fifth of a cub. centim.; the flask being shaken after each addition of the test fluid until the chlorid of silver had completely separated. 42·4 c. c. of this dilute solution of nitrate of silver were needed to complete the precipitation of the chlorine, = ·0424 grm. of silver.

Hence altogether 10·1278 + ·0424 = 10·1702 grm. of silver had been used.

10·1702 : 3·9942 :: 1349·66 (equiv. of Ag) : $x$

$x$ = 530·06 (equiv. of LiCl).

530·06 − 443·28 (equiv. of Cl) = 86·78 = equiv. of Li.

This number agrees sufficiently nearly with those derived from the two former experiments to show that all three are deserving of confidence. If we take the mean of the three, we shall have the number 86·89 for the equivalent of lithium; and this may, I believe, be fairly trusted as a closer approximation to the truth than any of the numbers hitherto received, if we take into account the greater scale upon which the analyses have been made, and the difference in the methods pursued. For it will be observed that the effect of the difficulty in determining sulphate of baryta already mentioned (namely the adherence of a little of the salt used for precipitation so as to scarcely permit its removal by washing) will necessarily be to increase the apparent per-centage of sulphuric acid in the sulphate of lithia analyzed, and hence to give a *lower* equivalent for the alkali than the true one. But this is the method by which the results hitherto most relied upon have been obtained.

The number 86·89 on the oxygen scale corresponds to 6·95 upon the hydrogen—thus making the equivalent of lithium almost exactly an even multiple of that of hydrogen, in accordance with the analogy which seems to extend further and further through the list of elements, as our knowledge of their atomic weights becomes more exact.

And further, if we take the mean of the equivalents of potassium and lithium, using 86·89 for the latter, we get—

488·86 (Marignac)
86·89

2)575·75

287·87 — almost exactly the equivalent of sodium (287·44) as determined by Pelouze.

ART. XXVII.—*On the Relations of the Fossil Fishes of the Sandstone of Connecticut and other Atlantic States to the Liassic and Oolitic Periods;* by W. C. REDFIELD.

Read before the American Association at Albany, Aug. 28, 1856.

IN the publications of Professor W. B. Rogers and Mr. E. Hitchcock, Jr., on the red sandstone beds of Connecticut, New Jersey and other States, founded on some of the contained fossils, a higher geological position than that of the New Red Sandstone has been assigned to the formation by these writers.* Without questioning their conclusions, I would here observe that the fossil fishes of these rocks are the most characteristic and apparently reliable fossils for determining the age of the formation. The determinative value of these fossils is perhaps enhanced, also, by the small vertical range to which some of the species, and at least one of the genera, are probably limited. But these fishes, although numerous as well as characteristic, do not appear to have been referred to, in any manner, by the above named writers.

Attention is invited, therefore, to a descriptive account of one genus or group of these fishes, which was read to the New York Lyceum of Natural History, in Dec. 1836, by Mr. John H. Redfield, and is found in vol. iv of the "Annals" of that Society. It

* Prof. W. B. Rogers *On the age of the coal rocks of Eastern Virginia*, Am. Jour. of Science, vol. xliii, p. 175, (1842). Also, in Proceedings of the Boston Society of Natural History, vol. v, p. 14, (1854).—E. Hitchcock, Jr., M. D. in Am. Jour. of Science, vol. xx, (N. S.) p. 22, (1855).

Prof. Rogers first assigns to the coal rocks of Eastern Virginia a position near the bottom of the Oolite formation of Europe; while from some fossils "discovered in a particular division of the New Red Sandstone of Virginia," he expects to be able confidently to announce the "existence of beds corresponding to the *Keuper* in Europe,"—doubtless in the extensions of the New Jersey Sandstones or *Newark group*. I propose the latter designation as a convenient name for these rocks, and those of the Connecticut valley, with which they are thoroughly identified by footprints and other fossils, and I would include also, the contemporary sandstones of Virginia and N. Carolina.

At a later period, (1854) Prof. Rogers recognizes the general equivalency of the eastern and middle belts of Virginia, and the eastern or Deep River coal belt of N. Carolina: all of which in his view ought to be placed in the Jurassic series, not far probably above its base. In relation to the more western belt, the occurrence of Posidoniæ, and Cypridæ, in Pennsylvania, with sauroid coprolites and imperfect impressions of *Zamites* leaves, he considers as sufficient to identify, as one formation, the disconnected tracts of this belt, in N. Carolina and Virginia and the prolonged area of the so-called New Red Sandstone of Maryland, Pennsylvania and New Jersey; and that they are of Jurassic date, but little anterior to the coal rocks of Eastern Virginia.

Prof. H. D. Rogers (1839) proposed the name of middle secondary to this group (for convenience sake) to distinguish it from the Appalachian formations on the one hand, and from the green sand deposits on the other.—Third Report on Geol. of Pennsylvania, p. 12.

Mr. Hitchcock describes a new species of *Clathopteris*, discovered in the sandstone of the Connecticut valley. This fossil fern, found near the middle of the series in Massachusetts, he refers to the liassic period.

was founded upon a careful comparison of the genus *Catopterus* with the fossil fishes of different formations in Europe, as these are portrayed in the great work of Prof. Agassiz, then recently received. Such portion of the description and observations then made as relate directly to the geological age of the formation are here quoted.

Of the genus *Catopterus*, species *C. gracilis*, he says:—"Tail forked, equilobed. Scales extending a little upon the base of the upper lobe." And in regard to the equilobed tail, he adds in a subjoined note:—"This indeed is not *strictly* the case. Its structure, however, is analogous to that of the *Semionotus*, ranked by Agassiz among the *Homocerci*, and differs most decidedly from that of the true *Heterocerci*, where the scales, and probably the vertebræ, extend to the extreme point of the upper lobe." He adds:—

"In the arrangement of Agassiz, this fish would be comprehended in the order *Ganoides*, and family *Lepidoides*. Its equilobed tail would assign it to the second division of the family, the *Homocerci*, as he has termed them. From seven fusiform genera now arranged in this division it is entirely excluded by the posterior position of its dorsal. It may therefore be ranked between the genera *Semionotus* and *Pholidophorus*, being analogous to both in the structure of the tail, and in its serrated fins, and to the latter in the articulation of the rays. From the situation of the dorsal fin I have thought the name *Catopterus* to be applicable to this new genus."—Annals Lyc. Nat. Hist. vol. iv, pp. 38–39.

Nearly twenty years have elapsed since the promulgation of these careful and apparently conclusive observations, which do not appear to have been weakened or set aside by any subsequent researches. It is proper to state that the two analogous genera above mentioned are found in the Oolitic series as well as in the Lias, and it is believed that few, if any of the kindred genera have a lower range.* The above observations afford at least sufficient warrant for the cautious and perhaps too limited

* A single case of semi-heterocercal structure as occurring in the coal rocks of Autun in France, was mentioned to us by Professor Agassiz in 1846. As we learn nothing more of its appearance in the palæozoic series, may there not possibly be an error as regards the authenticity or position of this fish? If otherwise it does not seem to have appeared again until after the Permian period. On the other hand, it appears to be admitted that the true heterocerques, of the *Palæoniscus* type, do not appear above the Trias, and I think they are not found above the Permian.

It should be noted that Sir. P. Egerton has described a most singular fish from the upper strata of the New Red, of a genus hitherto unknown, which has but little inequality in the structure of its caudal base. This fish, the *Dipteronotus cyphus* Eg., is very short and broad, with a double dorsal, and is altogether so *unique* in its character that its occurrence may be deemed to affect but little the chronological inferences which are drawn from the varied structure of the numerous genera and species of the Lepidoid family.—See Geol. Jour. 1854, p. 369, with a figure.

inferences with which Mr. R.'s paper in the Annals is concluded: viz.

"It has of late years been generally admitted that the sandstone from which these fishes are derived is of much later date than the old red sandstone, to which it was once referred, and these remains confirm this belief. The *Palæonisci*, of Europe [true heterocerques] have never been found below the coal measures, while they extend upward to the copper slate of the *zechstein*, or magnesian limestone. In the case before us, we find a species of *Palæoniscus* accompanied by a fish, the structure of whose tail approaches that of the *Pholidophorus*, and of other fishes never found below the lias. This fact would seem to imply for this formation, even a higher situation in the series than that which is now assigned it by geologists."—Annals, &c., p. 40.

The American Association of Geologists and Naturalists at the meeting held in Albany in April, 1843, requested Mr. John H. Redfield to prepare a report on the fossil fishes of the United States. His report was presented to the Association, at New Haven, in May, 1845. It was withheld from publication by its author, on account of the expected visit of Prof. Agassiz to this country, and with a view of commending the whole subject to his examination.—In the review of the fishes of our new red sandstone, so called, the report stated as follows:

"New Red Sandstone.—Under this term I include the extensive sandstone formation of the Connecticut river valley; the small and isolated basin on the Pomperaug river near Southbury, Ct.; the New Jersey Sandstone, extending from the border of the Hudson river, southwesterly, to the interior of Virginia; and, also, the formation known as the coal rocks of Eastern Virginia.—(Report, p. 4.)

"All of the fishes hitherto found in these rocks belong to the order Ganoidæ, and to the family Lepidoidæ."—Report, p. 5.

"Prof. Agassiz has made two subdivisions in this, as in other families of the order Ganoidæ, founded on differences in the structure of the tail. In the first of these, (*Heterocerci*) the upper lobe of the tail, is vertebrated and is usually longer than the lower, and the scales of the body extend upon the upper lobe nearly or quite to its extremity. The other division, the *homocerci*, have the tail regular, either forked or rounded, and the scales do not extend upon the upper lobe, though in some genera they are slightly prolonged in that direction. The fishes of our sandstone formation above mentioned, would seem to belong to the first of these divisions, or those with heterocercal tails. They do not, however, exhibit this structure in the same degree which obtains in the fishes of the older European rocks, or even in those of the new red sandstone or magnesian limestone of England and Germany. The only two genera which have yet been

found in our rocks differ somewhat from each other, also, in the degree of heterocercal structure which they present, those species which, following Prof. Agassiz in *P. fultus*, I have allotted to the genus *Palæoniscus*, having the heterocercal structure more decided. But even in these, the tail has a different aspect from the *Palæonisci* of Europe. In the latter, the upper lobe of the tail seems hardly to partake of the character of a fin, and the lower lobe appears to be only a fin-like appendage of the upper, like a second anal fin, while the scales and no doubt the vertebræ extend to the extreme point of the upper lobe."

"The other genus, the *Catopterus* of our rocks, exhibits the heterocercal structure in a still more modified degree. So nearly does it approach in this respect some genera classed as homocercal fishes, such as *Semionotus* and *Pholidophorus*, that in an early memoir published in the Annals of the Lyceum of Natural History, vol. iv, I was led to rank it in that division, subject to a qualifying note. Its relations are however, rather to the heterocercal fishes, or perhaps to an intermediate group."

"This point is an important one in its bearing upon geological questions, for it is now well ascertained that the true heterocercal tail [in the lepidoids] is peculiar to the palæozoic, and lower mesozoic rocks, no fish of that character having been found higher in the series than the triassic rocks, while the true [strict] homocercal tail does not occur below the lias. When therefore we find in the fishes of our sandstone rocks, a structure which seems to be intermediate between the true homocercal and the heterocercal divisions of Agassiz, the conclusion seems irresistible that the including rock *cannot be older* than the triassic, while it must be placed *at least as low* in the series as the lias or oolite." Report, pp. 5–6.

"— Only four species of the genus *Catopterus* are yet known; three of which are found in the red sandstone of New England and New Jersey and the fourth in the coal rocks of Eastern Virginia."* Report, p. 7.

His descriptions of these four species of *Catopterus* are found in the report, and were then prior to any known notice or description of these fishes, other than our own, and together with the descriptions of the more numerous species of the genus *Ischypterus*, are yet withheld from publication, on account of the contemplated arrangements for completing a monograph of the fishes of this formation in the United States.

I have thus shown the examinations and conclusions of Mr. J. H. Redfield on these fishes, as first published in 1837, and as found in his report to the American Association in 1845. In the first of these he points out the age of the containing rocks,

* Others have since been obtained.

and within the same limits which now appear to result from all the subsequent researches.

At the meeting of this Association held in Cincinnati in April, 1851, the present writer made a communication on the Post-Permian character of the red sandstone rocks of Connecticut and New Jersey as shown by their fossils. I then exhibited, together with two species of *Voltzia*, some specimens of the genus *Catopterus* from these rocks, showing the homology of their caudal structure with that of the *Catopterus macrurus* from the coal rocks of Eastern Virginia. This was induced in part by the fact that Sir Philip Egerton, in a paper of Sir Charles Lyell, in the Journal of the Geological Society, had separated this Virginia species from its congeners in the New Jersey and Connecticut rocks, on the ground that the former belonged to the homocercal and the latter to the heterocercal divisions of Prof. Agassiz.* Previous however to this publication of Sir Charles, repeated and careful examinations, with Prof. Agassiz, of the numerous specimens of Catopterus in my possession, collected from the localities of the three different States, had appeared to establish fully their similarity in respect to the structure of the tail. Also, that the *Catopteri* of all the localities, including Virginia, might continue to be referred to the *homocerci*, as in the case of several European genera, or that, more properly both they and the other fishes of these rocks might be referred to a distinct and intermediate division, which is *sub*-heterocercal in its character, if I may so speak. I therefore reclaim the *Dictyopyge* of sir Philip Egerton, founded on my species *C. macrurus*, as still belonging to the genus *Catopterus*. I refer to this matter on the present occasion on account of the important bearing which it has on the geological age of these fishes, as found in the several states.

It may be added in further explanation, that Sir Charles Lyell in the paper referred to, states that "the genus Catopterus was instituted by Mr. Redfield for certain species of heterocercal fish from the Connecticut red sandstone." He seems not to have noticed that the genus was instituted by Mr. J. H. Redfield in 1836 for a *homocercal* fish, according to the characteristics afforded in the *Poissons Fossiles* of Agassiz; and he probably alluded only to my own later notices in this Journal, 1841, vol. xli, p. 27. All the fishes obtained by him from the sandstone of the Connecticut river are also pronounced heterocercal, while the Virginia fish is stated to be homocercal, and this he supports by the opinions of Prof. Agassiz as given on first seeing his specimens

* Sir Charles Lyell *On the Structure and Probable Age of the Coal-Field of the James River, near Richmond, Virginia:* Jour. of the Geol. Soc., vol. iii, 1847, pp. 275–278.

of these fishes in Europe. Based on this designation, Sir Philip Egerton proposed his new genus *Dictyopyge* for the *C. macrurus* of the Virginia rocks.

In regard to the other fishes of New England and New Jersey, Mr. J. H. Redfield had reluctantly followed the work of Prof. Agassiz in assigning them to the genus *Palæoniscus*, although this eminent naturalist had then only seen two imperfect specimens; but Mr. R. then alluded to their structural affinity with the liassic fishes, as we have seen in his conclusion already quoted, and impliedly in the descriptive portion of his paper. It is well seen, also, in his figure of the *P. latus*, attached to his paper in the Annals. In my own notices of 1841, referred to above, I suggested that their less heterocercal forms, and the peculiar structure of their fins warrant their being placed in a separate genus. Sir Philip Egerton recognizes the division, as did Prof. Agassiz in 1846, and Sir Philip proposes for the new genus the name *Ischypterus*.

The question to which of the divisions of Agassiz the Catopterus of Connecticut and this fish of Virginia belong, is simply one of degree. Even if we were to admit a slight difference in this case, it could hardly imply the wide separation which has been claimed. Such a marked division, founded on the structure of the tail, cannot depend on the use of a term, but must be decided by the fishes themselves.

In regard to this point of distinction, may I not quote the matured views of Sir Philip Egerton, so well expressed in the Journal of the Geological Society, 1854, p. 368:—"Although this character, derived from the organization of the caudal fin, is one of great value and significance in the determination of various genera of fossil fishes, it is nevertheless necessary, in drawing general conclusions, to be careful not to assign to it more importance than it is strictly entitled to; for we find, by the comparison of several genera, that it is not one of those well defined trenchant characters which can be affirmed to exist or not, as the case may be, but that it is variable in amount, passing from extreme *heterocercy* to absolute *homocercy* by a sliding-scale so gradual, that it is (at all events in fossil examples) most difficult to define a positive line of demarcation between the two forms."

As the terms have hitherto been used, such line of demarcation, if it exist, appears best indicated at the division between the palæozoic and the mesozoic strata; and perhaps in lesser degree, at the close of the triassic period.

In all our *Catopteri* the scales of the caudal base terminate near the middle rays of the upper lobe, "and not on the upper margin, as in a true heterocerque tail."* Good figures by Din-

* See Egerton as last quoted p. 370.

kel of the species *C. macrurus* of Virginia are given in the abovementioned paper of Sir Charles Lyell.

It has been seen that Mr. J. H. Redfield considers the other fishes of the Connecticut river and New Jersey rocks as more heterocercal in degree than the Catopterus. In some of the species, however, this difference seems less obvious after a close examination of the structure, than it appears at first view. One or two of the species in my possession I think are even more nearly homocercal than the Virginia fish.

I desire to add, that two of the *Lepidoti* from the table land of India of which figures are given in the Jour. of the Geol. Society, show very strong resemblances to two or three of my fishes from the sandstone of Connecticut river at Sunderland, to one of which I had proposed the name *Ischypterus Marshii.* Is it not probable that the vast extent of sandstone and trap in that distant region, is of like age with our Newark group?

Already I have ventured to state verbally to the Association, that in the valuable collection of fossils from the coal-field of Deep River in North Carolina, now exhibited by Prof. Emmons, I have recognized several well characterized fragments of the genus Catopterus. A close comparison of these with specimens in my cabinet may perhaps show a difference of species. But my present impression is that of identity with one of the New Jersey species.

It would be premature to conjecture how far the new fossils of Prof. Emmons may affect the question of the relative age of these rocks. But when we consider that these fishes evidently belong to fresh water or estuary deposits, as is shown by the entire absence of any remains of large marine fishes, by an almost equal absence of shells, and by the numerous fossilized fragments of vegetation with which the fishes are associated, the chronological evidence afforded by their characteristic organization would seem to be more determinate than that of saurians, plants, or marine fishes, whose general habitat and power of distribution, enable them to occupy a greater range in the geological series.

P. S. It is proper to add, that having now compared the remains of *Catopterus* of Prof. Emmons's collection with my own specimens of the genus, I find them scarcely distinguishable from most of those of the New Jersey and Connecticut rocks. Indeed they appear to be identical with *C. gracilis.* The chief differences appear in the larger size of most of the Carolina specimens which may be due to conditions more favorable to their growth, and in the less flattened condition of the basal portion of the strong and elongate front ray of the pectoral fin,—owing, probably, to a nearly equal pressure on all sides, in the carbonaceous paste or sediment in which they were fossilized.

New York, Sept. 12th, 1856.

## Art. XXVIII.—*On the Application of the Mechanical Theory of Heat to the Steam Engine*; by R. Clausius.

[Continued from p. 203.]

27. The influence which the difference of the pressure in the boiler and in the cylinder exerts upon the work, has been treated probably most completely up to this time in the work of de Pambour (Théorie des Machines à vapeur), and I may be permitted before I myself take up the subject, to state in advance the most important points of this mode of treating it, only with a somewhat different notation and with the omission of the magnitudes which relate to the friction, in order to be able the more easily to show how far the theory no longer corresponds to our more recent knowledge of heat, and at the same time to connect with it the new mode of treating the subject, which in my opinion must take its place.

28. The two laws mentioned already at the beginning of this paper, which at that time were pretty generally applied to steam form the foundation of de Pambour's theory. First, the law of Watt, that the sum of the free and latent heat is constant. From this law, the conclusion was drawn, that if a quantity of steam at the maximum density be enclosed in a shell impenetrable to heat, and the cubic contents of this shall be increased or diminished, the steam will in this case be neither over-heated nor partially precipitated, but will remain exactly at the maximum density, and that this would take place quite independently of the mode in which the change of volume may occur, whether the steam had to overcome thereby a pressure corresponding to its expansive force or not. Pambour supposed that the steam behaved in the same way in the cylinder of the steam engine, inasmuch as he did not assume that the particles of water which in this case are mixed with the steam could exert a perceptible changing influence.

In order now to be able more nearly to express the connection which exists for steam at the maximum density, between volume and temperature or volume and pressure, Pambour applied in the second place the laws of Mariotte and Gay Lussac to steam. From these we obtain the equation

$$(28.) \qquad v = 1{,}696 \cdot \frac{10333}{p} \cdot \frac{273 + t}{273 + 100},$$

if we assume with Gay Lussac the volume of a kilogram of steam at 100°, at the maximum density, to be 1,696, and consider that the pressure thereby exerted by one atmosphere upon a square meter is 10,333 kilograms, and if we denote for any other temperature $t$, the volume and the pressure, assuming the same units,

by $v$ and $p$. In this equation we need only substitute for $p$ the known values from the tension series, in order to be able to calculate for every temperature the correct volume under these suppositions.

29. As, however, the integral $\int p\,dv$ plays a principal part in the formulas for the work of the steam engine, it was necessary to have the simplest possible formula between $v$ and $p$ alone, in order to be able to calculate this in a convenient manner.

The equations, which we should obtain if we were to eliminate the temperature $t$ from the foregoing equation, by means of one of the empirical formulas for $p$, would prove too complicated, and Pambour therefore proposed to form a special empirical formula for this purpose, to which he gave, according to the process of Navier, the following general form

$$v = \frac{B}{b+p}, \tag{29}$$

in which $B$ and $b$ are constants. He now sought to determine these constants in such a manner, that the volumes calculated from this formula corresponded as accurately as possible with those calculated from the previous formula. As this however, is not possible with sufficient accuracy for all the pressures which occur in steam engines, he calculated two different formulas, for machines *with* and *without* condensers.

The first is as follows:

$$v = \frac{20000}{1200+p}, \tag{29a}$$

and agrees best with the above formula (28) between $\frac{2}{3}$ and $3\frac{1}{3}$ atmospheres, is applicable however also in a somewhat wider interval, perhaps between $\frac{1}{2}$ and 5 atmospheres.

The second formula determined for machines without condensers, is on the other hand as follows:

$$v = \frac{21232}{3020+p}. \tag{29b}$$

It is most accurate between 2 and 5 atmospheres, and the whole interval of its applicability, extends about from $1\frac{1}{3}$ to 10 atmospheres.

30. The magnitudes depending upon the dimensions of the steam engine which occur in determining the work, shall here be denoted in the following manner, somewhat different from that of Pambour. Let the whole space which becomes free for the steam during a stroke in the cylinder, including the injurious space, be called $v'$. Let the injurious space form the fraction $\varepsilon$ of the whole space, so that thus the injurious space is separated by $\varepsilon v'$ and the space described by the surface of the piston by $(1-\varepsilon)v'$. Further let the portion of the whole space which has become

free for the steam up to the moment of cutting off the cylinder from the boiler, including also the injurious space, be denoted by $ev'$. Hence the space described by the surface of the piston, during the entrance of the steam will be expressed by $(e-\varepsilon)v'$ and the space described during the expansion by $(1-e)v'$.

In order now, in the first place, to determine the work done, during the admission of the steam, the active pressure in the cylinder during this time must be known. This is, in any event, smaller than the pressure in the boiler, since otherwise no influx of steam would take place; it cannot however be generally stated how great this difference is, since it not only depends upon the arrangement of the machine, but also upon how wide the engineer has opened the valve in the steam pipe, and upon the velocity with which the machine moves. This difference may vary between wide limits by changing these conditions. The pressure in the cylinder also is not necessarily constant during the whole time of the influx, because both the velocity of the piston and the magnitude of the influx opening left free by the steam valve or slide valve are variable.

Pambour assumes with reference to the last condition, that the mean pressure which is to be brought into the calculation in determining the work, can with sufficient accuracy be supposed equal to the pressure which is exerted in the cylinder at the end of the influx, at the moment of cutting off from the boiler. Though I do not consider it advantageous to introduce directly into the general formulas such an assumption, which is made only for the sake of numerical calculation in the absence of more certain data, yet I must here follow his process in setting forth his theory.

Pambour determines the pressure which takes place in the cylinder at the moment of the cut-off by means of the relation established by him between volume and pressure, inasmuch as he thereby supposes that the quantity of steam passing into the cylinder, during the unit of time and consequently also, during one stroke of the piston, is known by special observations. We will as before denote by $M$ the whole mass which enters the cylinder during a stroke of the piston, and that portion of it which is in the form of steam by $m$. As this mass, of which Pambour only considers the portion which is in the form of steam, fills the space $ev'$ at the moment of the cut-off, we have, if we denote the pressure at this moment by $p_2$ according to equation, (29)

$$ev' = \frac{m \,.\, B}{b + p_2},$$

whence we have

$$(30.) \qquad p_2 = \frac{m \,.\, B}{ev'} - b.$$

If we multiply this quantity by the space described by the surface of the piston up to the same moment, namely $(e-\varepsilon)\,v'$, we obtain for the first part of the work, the expression:

$$(31.) \qquad W_1 = m\,B\,.\,\frac{e-\varepsilon}{e} - v'\,(e-\varepsilon)\,b.$$

The law according to which the pressure varies during the expression which now follows, is also given by equation (29). Let the variable volume at any moment be denoted by $v$, and the corresponding pressure by $p$, and we have

$$p = \frac{m\,.\,B}{v} - b.$$

We must substitute this expression in the integral $\int p\,dv$ and and then execute the integration from $v=ev'$ to $v=v'$ by which means we obtain as the second part of the work

$$(32.) \qquad W_2 = m\,B\,.\log\frac{1}{e} - v'\,(1-e)\,b.$$

In order to determine the negative work done during the return of the piston, by the counter pressure, the counter pressure itself must be known. Without for the present entering upon the question how this counter pressure is related to the pressure which takes place in the condenser, we will denote the mean counter pressure by $p_0$, so that the work done by it, is represented by

$$(33.) \qquad W_3 = -\,v'\,(1-\varepsilon)\,p_0.$$

Finally, there still remains the work which must be applied to force the quantity of liquid M, again into the boiler. Pambour has not specially considered this work, but has included it in the friction of the machine. As I have however, taken it into consideration in my formulas, in order to have the cyclus of the operations complete, I will add it here also for the sake of a more easy comparison. If $p_1$ denotes the pressure in the boiler, and $p_0$ the pressure in the condenser, this work is represented as a whole by

$$(34.) \qquad W_4 = -\,M\sigma\,(p_1 - p_0),$$

as is deduced from equations (21) and (22) established in the example formerly considered. For our present case, in which we understand by $p$, not the pressure in the condenser itself, but in the part of the cylinder which is in connection with the condenser. This expression it is true, is not quite accurate; as however in consequence of the smallness of the quantity the whole expression has so small a value that it scarcely deserves consideration, we may neglect the more freely a small inaccuracy in comparison with the small value, and will therefore here also, retain the expression in the same form.

By the addition of these four single quantities of work, we obtain the whole work done during the circular process, namely,

$$(35.)\quad W' = mB\left(\frac{e-\varepsilon}{e} + \log\frac{1}{e}\right) - v'(1-\varepsilon)(b+p_0) - M\sigma(p_1-p_0).$$

31. It is only necessary to divide the foregoing value by $m$, if we wish finally to refer the work to the unit of weight of steam, instead of to a single stroke of the piston, during which the quantity of steam $m$ is acting. For this purpose, we will denote by $b$, the fraction $\frac{M}{m}$ which represents the relation of the whole mass which passes into the cylinder, to the portion of it in the form of steam, and which is consequently somewhat greater than 1; furthermore by $v$ the fraction $\frac{v'}{m}$, that is the space which is offered on the whole to the unit of weight of steam in the cylinder, and by the fraction $\frac{W'}{m}$ or the work corresponding to the unit of weight of steam. Then we have

$$(\text{XII.})\quad W = B\left(\frac{e-\varepsilon}{e} + \log\frac{1}{e}\right) - V(1-\varepsilon)(b+p_0) - l\sigma(p_1-p_0).$$

In this equation, there ocurs only one term which depends upon the volume $v$, and it contains $v$ as a factor. As this term is negative, it follows that the work which we can obtain by means of the unit of weight of steam, under otherwise equal circumstances, is greatest when the volume which is presented to the steam in the cylinder is the least possible. The smallest value of the volume to which, if we can never quite reach it, we can yet approximate more and more, is that which we find when we assume that the machine moves so slowly, or that the influx pipe is so wide that the same pressure $p_1$ takes place in the cylinder as in the boiler. This case gives thus the maximum work. If the rate of motion be greater with an equal influx of steam, or if with an equal rate of motion, the influx of steam be less, we obtain in both cases a smaller work by means of the same quantity of steam.

33. Before we proceed from this point to consider the same series of processes in their connection, according to the mechanical theory of heat, it will be advantageous to consider beforehand one of them singly, which still requires a special investigation to fix a priori the results relating to it, namely: the influx of the steam into the injurious space, and into the cylinder, when it has here to overcome a pressure less than that with which it is driven from the boiler. I can proceed in this investigation according to

the same principles which I have already applied to the treatment of several similar cases in a former paper.*

The steam coming from the boiler passes first into the injurious space, compresses here the steam still present from the previous stroke of the piston, fills the space which thereby becomes free, and acts then by pressure against the piston, which, according to our assumption, in consequence of a comparatively small load, yields so quickly that the steam cannot follow fast enough to attain in the cylinder the same density as in the boiler.

Under such circumstances, if only saturated steam passed from the boiler, this would be overheated in the cylinder, inasmuch as the living force of the motion of influx is here converted into heat; as however the steam carries some finely divided water with it, a part of this will be evaporated by the excess of heat, and will thereby retain the remaining steam in a state of saturation.

We must now propose to ourselves the problem: given, the initial condition of the whole mass to be considered, as well that already contained in the injurious space, as also that newly entered from the boiler, further, the quantity of work which is done during the influx by the pressure acting upon the piston, and finally the pressure in the cylinder at the moment of cutting it off from the boiler, it is required to determine how much of the mass in the cylinder is in the state of steam at this moment.

33. Let the mass in the injurious space, before the influx which for the sake of generality shall be assumed to be partly fluid and partly in the form of steam, be called $\mu$, and the portion of it, which is in the form of steam $\mu_0$. The pressure of this steam and the absolute temperature which it possesses may for the present be denoted by $p_0$ and $T_0$, without meaning to say that these are exactly the same values which hold good for the condenser also. The pressure and the temperature in the boiler

* *On the behavior of steam in expanding under different circumstances*, these Annals, vol. 82, p. 263. Helmholtz, in his report in the progress of physics, published by the Physical Society of Berlin, for the year 1850 and '51, p. 582, says with respect to this article and a notice connected with it and communicated in the Philosophical Magazine, that in his opinion the same is incorrect in principle, in many points. I have not been able to understand however, the reasons which he assigns for this. Views are ascribed to me which I never had, and propositions expressed in opposition to them which I have never contested, and which form in fact partly the foundation of my own works on the mechanical theory of heat, while the whole is treated in so general a manner that it has been impossible for me to determine how far these views follow from my words or these propositions are to overthrow my conclusions. I do not therefore see myself obliged to defend my former works against this blame. As however, the development which follows here rests as above mentioned, entirely upon the same views by which I was at that time guided, Helmholtz will perhaps find in it also the same errors in principle. For this case, I await his objections, only I would then desire him to go into the matter in a somewhat more special manner.

shall be called as before $p_1$, $T_1$, the mass flowing from the boiler into the cylinder $M$, and the part of it which is in the form of steam $m_1$. It is not necessary, as already mentioned, that the pressure exerted upon the piston during the influx, be constant. We will call this pressure the mean pressure, and will denote it by $p'_1$, by which the space described by the surface of the piston during the period of the influx must be multiplied, in order to obtain the same work which is done by the variable pressure. Let the pressure which actually takes place in the cylinder at the moment of the cut-off, be denoted by $p_2$ and the temperature by $T_2$, and let finally the quantity, with the determination of which we have to do, namely, the portion of the whole mass now present in the cylinder $M+\mu$, which is in the form of steam, be represented by $m_2$.

To determine this quantity, let us consider the mass $M+\mu$, in any manner brought back to its initial condition. The vaporized portion $m_2$, is condensed in the cylinder by the downward pressure of the piston, whereby it is supposed that the piston can also penetrate into the injurious space. Let at the same time so much heat be in any manner withdrawn from the mass, that its temperature $T_2$ remains constant. Then the portion $m_1$ of the whole fluid mass is pressed back into the boiler where it again assumes the original temperature $T_1$. The same condition is thereby restored in the boiler as before the influx, inasmuch as it is of no importance whether exactly the same mass, $m_1$ which was previously in the form of steam, is so now again, or whether an equally large other mass has taken its place. The remaining portion $\mu$ is first cooled down, in the fluid condition from $T_2$ to $T_0$, and at this temperature the portion $\mu_0$ is converted into steam, by which the piston moves so far that this steam can again assume its original space.

34. The mass $M+\mu$, has consequently gone through a complete circular process, to which we may now apply the theorem that the sum of all the quantities of heat taken up by the mass, during a circular process, must be equivalent to the whole external work performed in it. The following quantities of heat are taken up, one after another.

1. In the boiler, where the mass $M$ is heated from the temperature $T_2$ to $T_1$, and the portion $m_1$ must be converted into steam at the latter temperature:

$$m_1 r_1 + Mc(T_1 - T_2).$$

2. During the condensation of the portion $m_2$ at the temperature $T_2$:

$$- m_2 r_2.$$

3. During the cooling of the portion $\mu$ from $T_2$ to $T_0$:

$$- \mu c (T_2 - T_0).$$

4. During the evaporation of the portion $\mu_0$, at the temperature $T_0$:

$$\mu_0 r_0.$$

The whole quantity of heat which may be called $Q$, is consequently:

(36.) $$Q = m_1 r_1 - m_2 r_2 + Mc(T_1 - T_2) + \mu_0 r_0 - \mu c(T_2 - T_0).$$

The quantities of work are found in the following manner:

1. In order to determine the space described by the surface of the piston during the influx, we know that the whole space occupied by the mass $M+\mu$, at the end of this time, is

$$m_2 u_2 + (M+\mu)\sigma.$$

From this the injurious space must be subtracted. As this was filled in the beginning at the temperature $T_0$ for the mass $\mu$, of which the portion $\mu_0$ was in the form of steam, it may be expressed by

$$\mu_0 u_0 + \mu\sigma.$$

If we subtract this quantity from the previous one and multiply the remainder by the mean pressure, $p'_1$, we obtain as the first work:

$$(m_2 u_2 + M\sigma - \mu_0 u_0) p'_1.$$

2. The work, by the condensation of the mass $m_2$, is:

$$-m_2 u_2 p_2.$$

3. By forcing back the mass $m$ into the boiler

$$-M\sigma p_1.$$

4. By the evaporation of the portion $\mu_0$:

$$\mu_0 u_0 p_0.$$

By the addition of these four quantities, we obtain for the whole work $W$, the expression,

(37.) $$W = m_2 u_2 (p'_1 - p_2) - M\sigma(p_1 - p'_1) - \mu_0 u_0 (p'_1 - p_0).$$

If we substitute these values of $Q$, and $W$, in equation (1), namely,

$$Q = A \,.\, W$$

and bring the terms containing $m_2$ together on one side, we have

(XIII.) $$m_2[r_2 + Au_2(p'_1 - p_2)] = m_1 r_1 + Mc(T_1 - T_2) + m_0 r_0 - \mu c(T_2 - T_0) + A\mu_0 u_0 (p'_1 - p_0) + AM\sigma(p_1 - p'_1).$$

By means of this equation, we can calculate the quantity $m_2$ from the quantities supposed to be known.

35. In those cases in which the mean pressure $p'_1$ is considerably greater than the final pressure $p_2$, for instance, if we assume that during the greater part of the period of influx, nearly the same pressure has taken place in the cylinder as in the boiler, and that the pressure has first diminished to the lesser value $p_2$, by the expansion of the steam already in the cylinder, it may happen that we find for $m_2$ a value which is smaller than $m_1 + \mu_0$, that consequently a portion of the steam originally present is precipitated. If on the other hand, $p'_1$ be but little greater or in fact smaller than $p_2$, we find for $m_2$ a value which is greater than $m_1 + \mu_0$. This last is to be considered as the rule in the steam engine, and holds good in particular also for the special case assumed by Pambour that $p'_1 = p_2$.

We have consequently arrived at results which differ essentially from Pambour's views. While he assumes one and the same law for the two different kinds of expansion which occur in succession in the steam engine, according to which the steam, originally present neither increases nor diminishes, but always remains exactly at a maximum density, we have found two different equations, which permit us to recognize an opposite relation. According to the equation just found (XIII), new steam must still arise in the first expansion during the influx, and in the further expansion, after the cutting off from the boiler, whereby the steam does the full work corresponding to its expansive force, a portion of the steam present must be precipitated according to the equation (VII) already developed. As these two opposite actions of increasing and diminishing the steam, which must also exert a contrary influence upon the quantity of work done by the machine, partly counteract each other, the same final result may occur approximately under certain circumstances, as according to Pambour's more simple assumption. We must not however, therefore neglect to take into consideration the difference found, particularly when we desire to determine in what manner a change in the arrangement, or in the working of the steam engine, acts upon the quantity of its work.

36. By the help of the quantities of heat cited singly in § 34, we may according to what is stated in § 8, easily determine the uncompensated transformation which occurs during the expansion, by applying the integral which occurs in the equation

$$N=-\int\frac{dQ}{T}$$

to these quantities of heat.

The communication of the quantities of heat $m_1 r_1 - m_2 r_2$ and $\mu_0 r_0$, occurs at constant temperatures, namely $T_1$, $T_2$, $T_0$, and these portions of the integral are therefore:

$$\frac{m_1 r_1}{T_1}, -\frac{m_2 r_2}{T_2} \text{ and } \frac{\mu_0 r_0}{T_0}.$$

For the portions of the integral arising from the quanties of heat $Mc(T_1 - T_2)$ and $-\mu c(T_2 - T_0)$, we find, according to the process already applied in § 23, the expressions:

$$Mc \log\frac{T_1}{T_2} \text{ and } -\mu c \log\frac{T_2}{T_0}.$$

By putting the sum of these quantities in the place of the above integral, we obtain for the uncompensated transformation, the value:

$$(38.)\quad N=-\frac{m_1 r_1}{T_1}+\frac{m_2 r_2}{T_2}-Mc\log\frac{T_1}{T_2}-\frac{\mu_0 r_0}{T_0}+\mu c\log\frac{T_2}{T_0}.$$

37. We may now return again to the complete circular process which takes place during the working of the machine, and

consider as before the particular portions of the same in succession.

The mass $M$ flows from the boiler in which the pressure $p_1$ is assumed, into the cylinder, the part $m_1$ as steam, and the remainder as liquid. Let the mean pressure acting in the cylinder during this time be denoted as above by $p'_1$, and the final pressure by $p_2$.

The steam now expands until its pressure has sunk from $p_2$ to a given value, $p_3$ and consequently its temperature from $T'_2$ to $T_3$. The cylinder is thereupon put into communication with the condenser in which the pressure $p_0$ is exerted and the piston makes the whole motion just completed again in the opposite direction. The counter pressure which it thereby undergoes, is during a somewhat more rapid motion greater than $p_0$, and we will therefore, to distinguish it from this value, denote the mean counter pressure by $p'_0$.

The steam which remains at the end of the motion of the piston in the injurious space, which must be considered for the next stroke, is under a pressure which in like manner need be neither equal to $p_0$ nor $p'_0$ and may therefore be denoted by $p''_0$. It may be greater or smaller than $p'_0$ according as the cutting off from the condenser takes place somewhat before or after the end of the motion of the piston, inasmuch as the steam in the first place is compressed somewhat further, in the last case, on the contrary, has time to expand somewhat more by the partial influx into the condenser.

Finally the mass $M$ must be brought back from the condenser into the boiler, whereby as before the pressure $p_0$ acts to produce the effect and the pressure $p_1$ must be overcome.

38. The quantities of work done in these processes are represented by expressions quite similar to those in the simpler case already considered, only that the indices of the letters are changed in a manner which is easily understood, and the quantities which relate to the injurious space must be added. We thus obtain the following equations:

For the period of influx according to § 34, in which however $u''_0$ must be written instead of $u_0$.

$$(39.) \qquad W_1=(m_2 u_2+M\sigma-\mu_0 u''_0)p'_1.$$

For the expansion from the pressure $p_2$ to the pressure $p_3$, according to equation (IX) if $M+\mu$ is put in the place of $M$:

$$(40.) \quad W_2=m_3 u_3 p_3-m_2 u_2 p_2+\frac{1}{A}[m_2 r_2-m_3 r_3+(M+\mu)c(T_2-T_3)]$$

For the return of the piston, in which the space described by the surface of the piston is equal to the whole space occupied by the mass $M+\mu$ under the pressure $p_3$, less the injurious space represented by $\mu_0 u''_0+\mu\sigma$.

$$(41.) \qquad W_3=-(m_3 u_3+M\sigma-\mu_0 u''_0)p'_0.$$

For the forcing back of the mass $M$ into the boiler:

$$(42.) \qquad W_4 = -M\sigma(p_1 - p_0).$$

The whole work is therefore:

$$(43.) \quad W' = \frac{1}{A}[m_2 r_2 - m_3 r_3 + (M+\mu)c(T_2 - T_3)] + m_2 u_2 (p'_1 - p_2) + m_3 u_3 (p_3 - p'_0) - M\sigma(p_1 - p'_1 + p'_0 - p_0) - \mu_0 u''_0 (p'_1 - p'_0).$$

The masses $m_2$ and $m_3$ which occur herein may be found from equations (XIII) and (VII), in which it is only necessary to substitute in the first the value $p''_0$ in the place of $p_0$ to change in corresponding manner the quantities $T_0$, $r_0$ and $u_0$, and to introduce in the last the sum $M+\mu$ in the place of $M$. I will not, however, here completely execute the elimination of the two quantities $m_2$ and $m_3$ which is possible by these equations, but will only substitute its value for one of them $m_2$, because it is more advantageous for calculation to consider the equation so obtained together with the two already determined. The system of equations which serves to determine the work of the steam engine, is therefore in its most general form:

$$\text{XIV.} \quad \begin{cases} W' = \frac{1}{A}[m_1 r_1 - m_3 r_3 + Mc(T_1 - T_3) \\ \qquad + \mu_0 r''_0 - \mu c(T_3 - T''_0)] + m_3 u_3 (p_3 - p'_0) \\ \qquad + \mu_0 u''_0 (p'_0 - p''_0) - M\sigma(p'_0 - p_0). \\ m_2[r_2 + Au_2(p'_1 - p_2) = m_1 r_1 + Mc(T_1 - T_2) + \mu_0 r''_0 - \mu c(T_2 - T''_0) \\ \qquad + A\mu_0 u''_0 (p''_1 - p''_0) + AM\sigma(p_1 - p'_1) \\ \frac{m_3 r_3}{T_3} = \frac{m_2 r_2}{T_2} + (M+\mu)c \log \frac{T_2}{T_3}. \end{cases}$$

*(To be concluded.)*

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ART. XXIX.—*Examination of the Meteoric Iron from Xiquipilco, Mexico;* by W. J. TAYLOR.*

THE meteoric iron from Xiquipilco, Mexico, appears to have been first mentioned in the Gazeta de Mexico in 1784. It is stated there that small pieces of native iron, from a few ounces to fifty pounds in weight were very numerous, which were sought for by the Indians after heavy rains, who used them for manufacturing agricultural implements.

In a dissertation on metallic meteorites by Prof. W. S. Clark, the following notices of its literature are given:—Ann. des Mines Ser. 1, t. 2, p. 337. Gazeta de Mexico, 1784–5, vol. i., pp. 146, 200. Klaproth Beiträge zur chemischen Kenntniss der Mineral Körper, B. 4, s. 101. Sonnenschmit, Beschriebung der vorzug-

* From the Proceed. Acad. Nat. Sci. of Philadelphia, vol. viii, No. 3.

lichsten Bergwerke. Reviere de Mexico 1804, p. 192 and 288. Chladni (U. F. M. S. 336) Partsch, (D. M. S. 99.)

In the examination made by M. Berthier he failed to detect the presence of cobalt, but it is mentioned by Prof. Clark that Manross had found it in a specimen from the cabinet of Prof. Wöhler; my examination confirms that of Mr. Manross.

To the kindness of W. S. Vaux, Esq., I am indebted for the material for this investigation; Mr. Vaux has in his magnificent cabinet the principal portion of a mass which weighed over ten pounds. It was originally about six inches long, with an average diameter of three inches; the lump was oblong with rounded ends, the whole being covered with a thin crust of limonite.

A cross section cut from this lump has been carefully polished and etched by strong nitric acid, which gives a most beautiful surface of about three and a half inches in length, by two and a half in breadth, covered with the greatest complexity of widmannstattian figures which almost defy description.

The surface is crossed by bands about one-tenth to one-sixteenth of an inch in breadth; these apparent bands are cross sections of different planes, as is readily perceived by their different refractive powers.

On changing the position of the specimen, those that are a bright silvery white in one direction, become a dull grey in another, and vice versa.

There are several systems of bands, which preserve a parallelism among themselves and cross other systems at various angles, forming trapezoids, rhombs and triangles. These several fields and their characteristic etchings will be described in detail at some future time. Along the bands or planes, thin laminæ of schreibersite have been observed, as in other meteoric irons.

Imbedded in one side of the large lump (just described) was a globule of pyrrhotine, which looks as if it had been dropped into the iron when it was in a semi-fluid state. This globule appears to have been about an inch in diameter: it was in part decomposed; but a small portion of the mineral was separated sufficiently pure for the determination of its specific gravity and analysis. On dissolving it in hydrochloric acid, thin laminæ of schreibersite separated with minute portions of chromic iron.

Through the kindness of Dr. F. A. Genth, I have been permitted to make the following analysis in his laboratory:

Pyrrhotine dissolved in nitric acid, gave—

| | | | |
|---|---|---|---|
| No. 1. | Sulphur, | 33·76 | per cent. |
| | Iron, | 57·95 | " |
| | Nickel, | 6·70 | " |
| | Cobalt, | ·56 | " |
| | Silicon, | ·05 | " |
| | Phosphorus, | ·25 | |
| | | 99·27 | " |

No. 2 dissolved in hydrochloric acid, gave

| | | |
|---|---|---|
| Iron, | 58·25 | per cent. |

A residue remained, which dissolved after being treated with hydrochloric acid and chlorate of potash: it consisted of

| | | |
|---|---|---|
| Copper, | 0·12 | per cent. |

The remainder consisted principally of chromic iron, with a small portion of schreibersite.

The specific gravity was found to be 4·822.

The ratio of sulphur to the metals was found to be

| | | | |
|---|---|---|---|
| Sulphur, 2·102, | Iron, | 2·066, | 2·301. |
| | Nickel and Cobalt, | 0·245, | |

It will be seen that the composition corresponds with that of pyrrhotine, considering its formula to be FeS, if we disregard the few impurities which were found with it.

The meteoric iron was first treated in a flask with hydrochloric acid, and the gas evolved was passed through a solution of ammonia chlorid of copper, but not a trace of sulphur could be detected in this manner.

In the fifth supplement to Rammelsberg's Handwörterbuch der chemischen Mineralogie, this meteoric iron is mentioned as passive, experiments having been made by Prof. Wöhler; but the piece belonging to Mr. Vaux is evidently active, throwing down metallic copper from a neutral solution of its sulphate. This experiment was repeated with great care with confirmatory results.

No. 1 was dissolved in hydrochloric acid, and a slight precipitate was obtained by hydrosulphuric acid, which on a careful examination before the blowpipe, was found to be copper with a trace of tin.

| | | |
|---|---|---|
| Iron, | 90·72 | per cent. |
| Nickel, | 8·49 | " |
| Cobalt, | ·44 | " |
| Schreibersite, Chromic iron, &c., | ·38 | " |
| Silicon, | ·25 | " |
| Phosphorus, | ·18 | " |
| | 100·46 | |

The phosphorus was estimated in a separate portion which was first oxydized by nitric acid and fused in a platinum crucible with carbonate of soda.

No. 2 was dissolved in nitric acid.

| | | | |
|---|---|---|---|
| It gave, | Iron, | 90·37 | per cent. |
| | Nickel, | 7.79 | " |
| | Insoluble residue, | 1·91 | " |
| | | 100.07 | |

ART. XXX.—*On the Heat in the Sun's Rays;* by ELISHA FOOTE.

(Read before the Amer. Association for the Advancement of Science, Aug. 23, 1856.)

THE experiments here detailed were instituted for the purpose of investigating the heat in the Sun's rays.

Two instruments have been used for this purpose. One was Leslie's differential thermometer. Both bulbs of it were blackened by holding them in the smoke of burning pitch. When experimenting one was shaded, the other was exposed to the direct action of the sun's rays; and as both were thus equally subject to all other influences, the result was not affected by them.

Generally, however, I have found it more convenient to use two mercurial thermometers, and note their difference. Two small and very delicate instruments were procured as nearly alike as possible. The stems of both were attached to the same plate about two inches apart, and the scales were marked upon it in juxtaposition, so that the eye could see the indications of both at the same time. Both bulbs were blackened as in the other instrument. It was used in the same manner. The temperatures in the sun and in the shade were noted, and their difference was taken as equivalent to the indications of the differential thermometer.

The question that first arises is, does the difference between the shaded and exposed bulbs afford a correct measure of the heat in the sun's rays? To this point I would ask attention before proceeding to the experiment.

The theory of the differential thermometer was accurately investigated by Leslie. In one of the foci of two parabolic reflectors he placed a tin canister which was heated or cooled by putting in liquids of different temperatures or frigorific mixtures. In the other, the heat was received on one of the bulbs of his differential thermometer: and under all circumstances, the indications of the instrument were found to be accurately proportional to the differences between the temperatures of the canister and those of the surrounding air.

I have varied these experiments by keeping the canister at the uniform heat of boiling water in different temperatures of the air, and by substituting other sources of heat, and have always found the results to accord with those obtained by the distinguished philosopher to whom I have referred.

The principles of radiation lead to the same result; for while the differential thermometer receives heat from the canister, it at the same time radiates it to surrounding bodies, and that in pro-

portion or nearly so to the difference between its temperature and that of the medium in which it is placed.

I regard it therefore as well established that the differential thermometer affords a correct measurement of the *differences* between the heat of the canister and that of the surrounding air. These differences may evidently be varied in two ways: by changing either—

1st. The heat of the canister; or—

2dly. The temperature of the air.

An increase or diminution in the heat of the canister would directly increase or diminish the differences; whilst an increase in the temperature of the air would diminish the difference until an equality between the two was obtained. If the temperature of the air were uniform and the changes were those of the canister alone, the instrument measuring the differences would correctly indicate those changes. But if the heat of the canister were uniform and that of the air were varied, then would the instrument equally indicate those changes, but in a contrary direction. In case the heat of both the canister and the air was varied at the same time, if we knew the change in one and its effects upon the instrument, we could *easily* deduce the changes in the other. Suppose, for example, an increase of ten degrees on the scale of the instrument and an elevation of five degrees in the temperature of the air; the effect of the latter having been to depress the thermometer five degrees, and the canister having not only overcome that effect but increased the indications ten degrees, the sum of the two or fifteen degrees would be the real change which had taken place in the heat of the canister. Had there been a depression in the temperature of the air, it obviously should be subtracted from the indications of the instrument to obtain the desired measurement.

It is upon these principles that I have applied the differential thermometer to measure the comparative heat in the sun's rays. One of its bulbs received their direct action in the same way that it received the rays proceeding from the canister. The temperature of the air was at the same time obtained by a common thermometer. An increase was added to, and a diminution subtracted from, the indications of the instrument to obtain the real changes in the heat of the rays proceeding from the sun.

My first experiment was of the simplest kind. It was a winter's day. The differential thermometer was placed on the outside of a window where the temperature was below the freezing point. The effect measured by the scale (which merely divided the stem into equal parts) was 53°. It was then placed on the inside of the window where the temperature was about 70°, and to my surprise the effect rose to 115°. The experiment was many times repeated with similar results, although varying

some in amount from the different degrees of brightness in the sun. The change in the temperature of the air was still to be added, and the conclusion seemed to be irresistible, that the sun's rays in passing into the heated room acquired a temperature that they did not derive from the sun.

The experiment was next repeated with different temperatures of the room, and it was found that the intensity of the rays depended upon the heat of the room. Indeed in the coldest weather in winter I could impart to them a power which belonged to a summer's sun.

At a later period when the circumstances were changed and the heat on the outside had become greatest, the indications of the instrument were reversed. The high temperature of the summer rays was in a great measure lost or dissipated on entering into a cool room. There they had no greater power than had been found at similar temperatures in the winter.

For the purpose of a more accurate investigation of the subject, I procured a glass shade or receiver about ten inches in diameter and twenty-two in height. A copper base was adapted to it with a groove around the outer edge into which the receiver fitted; and when it was filled with dry ashes the point was thereby rendered sufficiently air-tight. It was supported by legs so high that a spirit lamp could be placed under it, and any required temperature given to the air within.

A second receiver of the same size was sometimes used for the purpose of simultaneous comparison. The air within it was cooled by inserting a tin canister filled with frigorific mixtures. The thermometers were supported within the receivers, and thus at the same time the same rays could be tested in the opposite extremes of temperatures.

I subjoin, as an example, the following table (p. 380) containing the results of an experiment made in February last, at eight o'clock in the morning. It was a clear day and the sun shone through a window into the room where the instruments were placed.

The first observation was the temperature of the room and in the sun upon a mercurial thermometer. The lamp was placed under the receiver, and as the temperature of the air was gradually increased, the effect was noted until the heat in the sun had attained the highest limit of the thermometer. The fourth column contains the differences between the thermometer in the shade and the one in the sun. The fifth column shows the true relative heat of the sun's rays at the different temperatures. It was obtained as before explained by adding to the differences the increase in the temperature of the air. Several observations may be made in regard to the results in the table.

| No. of obs. | Temp. of air. | Temp. in sun. | Diff. | Relative heat of sun's rays. |
|---|---|---|---|---|
| 1 | 40 | 46 | 6 | 6 |
| 2 | 44 | 50 | 6 | 10 |
| 3 | 48 | 56 | 8 | 16 |
| 4 | 50 | 60 | 10 | 20 |
| 5 | 54 | 66 | 12 | 26 |
| 6 | 58 | 70 | 12 | 30 |
| 7 | 63 | 80 | 17 | 40 |
| 8 | 70 | 90 | 20 | 50 |
| 9 | 78 | 100 | 22 | 60 |
| 10 | 83 | 106 | 23 | 66 |
| 11 | 88 | 110 | 22 | 70 |
| 12 | 98 | 120 | 22 | 80 |
| 13 | 102 | 124 | 22 | 84 |
| 14 | 108 | 130 | 22 | 90 |

1st. That the heat in the sun's rays is not uniform, such as would proceed from a great heated body of uniform intensity, nor is it such as was received from the canister, when kept at the same degree of heat, but that it varies and is dependent upon the temperature of the air.

2ndly. That the effects of the sun's rays upon the thermometer at the different degrees of heat in the receiver is the same that has usually been observed at similar temperatures in the open air. It is easy by changing the heat within the receiver, to imitate the power of the sun's rays that has been observed at any time or in any place; indeed at the same time, the same rays may have in one receiver the burning heat of a summer's sun, and in the other only the feeble action of winter.

3dly. It appears that heat does not travel along with the rays of light as has been usually supposed, but that it is received, or parted with, lost or acquired, according to the temperature of the place that the rays illuminate. The same rays that within the receiver have the high intensity belonging to summer, on passing to the outside, are reduced again to a winter's temperature.

In view of these results it seems to me to accord better with the facts to attribute to the sun's rays, perhaps to all light, an action of some kind on such heat as they come in contact with, producing thereby the effects that we have been accustomed to attribute to an enormous temperature in the sun. Each planet may be supposed to possess its own atmosphere of heat: this will be affected by the sun's light as the heat within the receiver was affected; but they need not be frozen by their great distance, nor burned by their near approach to the great luminary.

It becomes an interesting and important enquiry, to ascertain the circumstances that affect the action of light on heat.

One of the most obvious is, that the amount of action depends upon the quantity of light. The clearness of the atmosphere always affects the experiment, making it somewhat difficult to compare observations taken at different times. A strong light obtained by reflection or otherwise, always increased the

effect. But the most striking results were obtained by concentrating the rays with a lens. One was placed in the receiver with its focus directed upon an additional thermometer, the second and third columns in the following table contain the temperatures of the air and in the sun, and the fourth, the heat in the focus, while the air in the receiver was heated as before. The atmosphere at the time was not entirely clear.

| No. of obs. | Temp. of air. | Temp. in sun. | Heat in focus. |
|---|---|---|---|
| 1 | 76 | 82 | 104 |
| 2 | 78 | 88 | 114 |
| 3 | 80 | 90 | 120 |
| 4 | 84 | 96 | 130 |
| 5 | 90 | 102 | 138 |
| 6 | 100 | 110 | 148 |
| 7 | 104 | 114 | 152 |

The burning glass was then so arranged that being within the receiver its focus was on the outside. The result was as follows:

| No. of obs. | Temp. of air. | Temp. in sun. | Heat in focus. |
|---|---|---|---|
| 1 | 44 | 50 | 60 |
| 2 | 51 | 60 | 60 |
| 3 | 58 | 68 | 62 |
| 4 | 62 | 72 | 62 |
| 5 | 73 | 83 | 60 |
| 6 | 96 | 106 | 58 |

Then the burning glass was placed on the outside of the receiver and so arranged that its focus should be on the inside, and the effect was the same as if both glass and focus had been on the inside.

It will be observed that the effect of the burning glass is simply to increase the results before obtained. Its power depends upon the temperature of the place at which the light is concentrated. That no heat travels with the light is rendered more manifest. The increased temperature of the rays on the inside had no effect at their focus on the outside.

The power of the burning glass seems therefore to depend on two considerations: 1st, the amount of light concentrated, 2ndly, the amount of heat on which it acts.

Those who have heretofore sought its best effects have, it seems to me, too much neglected the latter consideration. Its greatest power is to be obtained by concentrating the greatest amount of light on the highest degree of artificial heat. The combination of the two may perhaps have important practical applications. The chemist may possibly produce new results by adding to the highest resources of artificial heat the powerful agency of concentrated light.

The subject is unfinished, and it is my intention to resume it on some future occasion.

## Art. XXXI.—*Circumstances affecting the Heat of the Sun's Rays;* by Eunice Foote.

(Read before the American Association, August 23d, 1856.)

My investigations have had for their object to determine the different circumstances that affect the thermal action of the rays of light that proceed from the sun.

Several results have been obtained.

First. The action increases with the density of the air, and is diminished as it becomes more rarified.

The experiments were made with an air-pump and two cylindrical receivers of the same size, about four inches in diameter and thirty in length. In each were placed two thermometers, and the air was exhausted from one and condensed in the other. After both had acquired the same temperature they were placed in the sun, side by side, and while the action of the sun's rays rose to 110° in the condensed tube, it attained only 88° in the other. I had no means at hand of measuring the degree of condensation or rarefaction.

The observations taken once in two or three minutes, were as follows:

| Exhausted Tube | | Condensed Tube. | |
|---|---|---|---|
| In shade. | In sun. | In shade. | In sun. |
| 75 | 80 | 75 | 80 |
| 76 | 82 | 78 | 95 |
| 80 | 82 | 80 | 100 |
| 83 | 86 | 82 | 105 |
| 84 | 88 | 85 | 110 |

This circumstance must affect the power of the sun's rays in different places, and contribute to produce their feeble action on the summits of lofty mountains.

Secondly. The action of the sun's rays was found to be greater in moist than in dry air.

In one of the receivers the air was saturated with moisture—in the other it was dried by the use of chlorid of calcium.

Both were placed in the sun as before and the result was as follows:

| Dry Air. | | Damp Air. | |
|---|---|---|---|
| In shade. | In sun. | In shade. | In sun. |
| 75 | 75 | 75 | 75 |
| 78 | 88 | 78 | 90 |
| 82 | 102 | 82 | 106 |
| 82 | 104 | 82 | 110 |
| 82 | 105 | 82 | 114 |
| 88 | 108 | 92 | 120 |

The high temperature of moist air has frequently been observed. Who has not experienced the burning heat of the sun that precedes a summer's shower? The isothermal lines will, I think, be found to be much affected by the different degrees of moisture in different places.

Thirdly. The highest effect of the sun's rays I have found to be in carbonic acid gas.

One of the receivers was filled with it, the other with common air, and the result was as follows:

| In Common Air. | | In Carbonic Acid Gas. | |
|---|---|---|---|
| In shade. | In sun. | In shade. | In sun. |
| 80 | 90 | 80 | 90 |
| 81 | 94 | 84 | 100 |
| 80 | 99 | 84 | 110 |
| 81 | 100 | 85 | 120 |

The receiver containing the gas became itself much heated—very sensibly more so than the other—and on being removed, it was many times as long in cooling.

An atmosphere of that gas would give to our earth a high temperature; and if as some suppose, at one period of its history the air had mixed with it a larger proportion than at present, an increased temperature from its own action as well as from increased weight must have necessarily resulted.

On comparing the sun's heat in different gases, I found it to be in hydrogen gas, 104°; in common air, 106°; in oxygen gas, 108°; and in carbonic acid gas, 125°.

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ART. XXXII.—*Review of a portion of the Geological Map of the United States and British Provinces by Jules Marcou;** by WILLIAM P. BLAKE.

GEOLOGICAL maps of the United States published in Europe and widely circulated among European geologists, are necessarily regarded by us with no small degree of attention and curiosity. This is more especially true, when such maps embrace regions of which the geography has only recently been made known and the geology has never before been laid down on a map with any approach to accuracy.

The recent geological map and profile by M. J. Marcou, which has appeared in the Annales des Mines and in the Bulletin of

* Carte Géologique des Etats-Unis et des Provinces Anglaises de l'Amérique du Nord par Jules Marcou. *Annales des Mines*, 5e Série, T. vii, p. 329. Published also with the following:

Résumé explicatif d'une carte géologique des Etats-Unis et des provinces anglaises de l'Amérique du Nord, avec un profil géologique allant de la vallée du Mississippi aux côtes du Pacifique, et une planche de fossiles, par M. Jules Marcou *Bulletin de la Société Géologique de France.* Mai, 1855, p. 813.

the Geological Society of France, presents us, in addition to the geology of the Atlantic States, a view of the geology of the broad and comparatively unknown region between the Mississippi and the Pacific. Representing regions which have not been visited by the person making it, such a map is necessarily a work of compilation, inference and generalization, and in the present state of our knowledge, some errors are to be expected. I will not undertake to say how far the author has faithfully used the means in his power for making a good geological map, but as there are errors too important to pass unnoticed, I will simply point out those which are most glaring and most likely to mislead foreign geologists. I shall confine myself solely to the western part beyond the Mississippi.*

Commencing on the Pacific coast, the peninsula of San Francisco is represented as composed of erupted and metamorphic rocks, being colored the same as the Sierra Nevada and Appalachians. The rocks of that peninsula, and on both sides of the Golden Gate, are chiefly sandstone and shale, and the same formation extends along the shores of the Bay to and beyond San José. Not only the extent and position, but the lithological characters of these rocks are discussed in a published report,† which was in the hands of the author of the map previous to its publication. The representation of the granitic rocks is not confined to the end of the peninsula, but is continued southward to the western shores of the Tulare lakes where the formations are chiefly miocene tertiary, the eruptive rocks scarcely appearing.

The promontory called Point Pinos, which forms the headland of the Bay of Monterey, is represented as tertiary, while a porphyritic granite constitutes the whole point and forms the coast-line south to the Bay of San Carlos, and is probably continuous southward to San Luis Obispo; forming a high and unbroken line of coast, all of which is colored tertiary on the map. Casting the eye further south, we find the color denoting the eruptive and metamorphic rocks again usurping the place which should be colored tertiary, at Point Conception, which consists of beds of conglomerate and sandstone.

The broad alluvial tract at the head of the Gulf of California —the Colorado desert—is made to extend nearly due north and parallel with the Colorado to the Soda Lake. The published description of this valley gives its direction as northwest and southeast, extending to the foot of San Bernardine Mountain.

* A former map by M. Marcou, published at Boston a little over two years since, was reviewed in vol. xvii, of this Journal. The present map is in part open to the same criticisms.

† Preliminary Geological Report on the Pacific Railroad Route, surveyed by Lieut. R. S. Williamson in California, House Doc., 129, Washington, D. C., Jan. 1855.

The extensive coal-fields of Puget Sound and the Coast of Oregon are represented as *Upper* Carboniferous or of the true coal-period. All the evidence which can be procured concerning the age of these deposits shows them to be Tertiary. The resemblance of the sandstone found with the coal to that of San Francisco, and the presence of *Pectens* in it has been noticed in published reports. Observations by Prof J. S. Newberry reported since the publication of the map show that these coal-deposits are undoubtedly Tertiary.*

In the region of the Wind River mountains, a range called the Black Hills, extending northeast of the Platte, has found a place in most of our maps. We find the geological structure of this range indicated on the map, as granitic and carboniferous, while on another map published in Gotha, it is represented as composed of cupriferous trap. A recent exploration of that region by Lieut. G. K. Warren, U. S. A., shows that this range is purely imaginary and should not appear on the maps north of the Platte.

According to the map, the region of the South Pass is occupied by a belt of cupriferous trap, extending over at least two degrees of longitude, and in a northeast and southwest direction, with the same trend as Keweenaw point and Isle Royale, Lake Superior. There is no record of any such outcrops as this in any of the reports of explorers who have visited that region. Fremont, Stansbury and others, found horizontal sedimentary formations resting on granitic rocks.†

The Wind River range, which according to Col. Fremont and his collection, is granitic and metamorphic, trending north-westerly, is not represented on the map. Fremont's peak, however, the highest peak of the range, and described by Fremont as composed of granite, gneiss, syenite, and syenitic gneiss, is represented as a *volcano*. The Raton Mountains are also colored as volcanic; in Abert's Report they are described as sedimentary, and coal-plants were obtained there and figured in the report.‡

These, however, are but inconsiderable errors when compared with the representation of the geological age of the strata forming the broad table lands on each side of the great central chain of mountains. These are represented as *Jurassic* above and *Triassic* below. The Jurassic forms a conspicuous feature on the map and includes the Llano Estacado, and all the table-lands from the Missouri to the Rio Grande. It is surrounded by a

* Proceedings of the American Association for the Advancement of Science, Albany, 1856.

† See the descriptions of the collections by Prof. James Hall, and report of Col. J. C. Fremont, p. 295.

‡ Report of an Examination of New Mexico, by Lieut. J. W. Abert, U. S. Top. Engineers, 1848

much broader coloring representing the trias. Yet there is no sufficient evidence of the presence of Jurassic formations, and the Llano and other plateaux referred to that age are not Jurassic, but Cretaceous.

The evidence brought forward to show the presence of the Jurassic, consists of one species of *Gryphæa* and one of *Ostræa*. They were obtained from the upper strata of Pyramid Mount—one of the mounds separated from the Llano Estacado by erosion. The Gryphæa is said to have the greatest analogy with *G. dilatata* of the Oxford clay of England and France, and was provisionally called *G. Tucumcarii*. The Ostræa is reported to bear much resemblance to *O. Marshii* of the inferior Oolite of Europe.* In the text accompanying the map the species are announced as identical, one with *G. dilatata*, the other with *O. Marshii*. Even if this identity be admitted, it does not authorize the conclusion that the strata are beyond question Jurassic; or if it did, the occurrence of Jurassic at that one point on the Canadian, would not authorize us to conclude that the formation extends for more than a thousand miles on both sides of the mountains. The genus Gryphæa in America is eminently characteristic of the Cretaceous formation, and species which very closely resemble *G. Tucumcarii*, if not in fact identical with it, are very abundant in Alabama and New Jersey in the Cretaceous formation. Moreover, all the species are found with many variations according to the locality. The abundance and variety of the species of this genus render it unsafe to regard *G. Tucumcarii*, however much it may resemble *G. dilatata*, conclusive evidence of the presence of oolitic formations. Specimens of the Gryphæa are found in the government collection, but there are none of the Ostræa.

Some of the evidences of the Cretaceous age of the Llano may now be presented. If we follow the strata in which the *Gryphæa* was procured, westward, we find them extending across the mountain chain, through the passes, into the valley of the Rio Grande, and here near the summit of the table-lands just south of Santa Fé, Mr. Marcou reports the presence of Cretaceous fossils. Farther west, at Poblazon near the Puerco, Lieutenant Abert obtained several specimens of *Inoceramus*† from horizontal strata. The topography at this point is the same as along the valley of the Canadian, the strata are at nearly the same elevation, and their mineral characters are similar. Numerous specimens of *Inoceramus* have also been obtained by Simpson,‡

* See Resumé of a Geological reconnoissance, &c. Report of Lieut. A. W. Whipple, U. S. Top. Engrs., H. Doc. 129, chap. vi.

† Described and figured by Prof. Bailey—Report by Lieut. J. W. Abert, U. S. Top. Engrs. of an Examination of New Mexico.

‡ Report aad Map of the Route from Fort Smith, Arkansas, to Santa Fé, by Lieut. J. H. Simpson, U. S. Top. Engrs., Washington, 1850.

Wislizenus and others along the valley of the Canadian river not far from Pyramid Mount, where the *Gryphæa* was procured. Farther east on the False Washita and near the Canadian, the Cretaceous fossil *Gryphæa Pitcheri* occurs in abundance and near the great beds of gypsum. Leon Spring, in the southern part of the Llano, has afforded abundance of Cretaceous fossils, and this place is represented on the map as Jurassic. Cretaceous fossils were also obtained by Capt. Pope from the bluffs of the Llano at the Sulphur Springs of the Colorado and from the surface of the plateau near the Sand Hills.* The Llano of Texas is well known and is undoubtedly the continuation of the Llano Estacado. The bluffs are filled with Cretaceous fossils already described by Ferdinand Rœmer. They are correctly represented as Cretaceous on the map.

The map displays a most remarkable relation of position between the Cretaceous and the "Jurassic" along the valley of the Rio Grande between El Paso and the mouth of the Pecos. The river has cut its valley downwards through the horizontal formations of the Llano which form bluffs on each side. On the map we find the valley of the stream colored as Cretaceous, while the higher strata of the Llano, are colored as Jurassic. Thus, according to this representation, the Jurassic strata overlie the Cretaceous. This conclusion is unavoidable unless we are ready to believe that the Cretaceous strata were deposited since the erosion of the valley of the Rio Grande. The same alternative is presented to us along the Upper Missouri; the highest table-land is colored as Jurassic, and the Cretaceous is made to crop out lower down nearer the river and rests directly upon the formation called Trias.

But the most striking feature of the map remains to be noticed. We find an area equal to that of all the States east of the Mississippi colored as Triassic. The section also represents this formation as enormously thick, and with four divisions corresponding to those in Europe. The color is extended on the map along the whole course of the Missouri down to Council Bluffs, and south into Texas, and is carried east so as to reach and border the southern shore of Lake Superior. The basis of this representation is chiefly the occurrence of red gypseous strata along the False Washita and Canadian rivers. The upper limit of the formation is considered to be at the base of the so-called Jurassic strata of the Llano, and its lower upon the Carboniferous.

The representation of this broad area as Triassic is made without the evidence of a single characteristic fossil, the principal support for it being the position and mineral characters of the strata. It is said that they are like those of Windsor and Plaister Cove, N. S., which were supposed to be Triassic but have since been shown by Mr. Dawson to be Carboniferous.† Hence the

* Report on the Geology of the Route surveyed by Bvt. Capt. Pope, U. S. Top. Engrs., 4to. Washington, 1856. [Pacific R. R. Exp. and Surveys.]

† Acadian Geology, by J. W. Dawson. Edinburgh, 1855.

similarity indicates a Carboniferous age rather than Triassic. The limit of the formation above or below, although perhaps well defined at one point, may not be at others, or may be very different; the red color of the strata—the only guide—being the result of chemical changes and not of original deposition. The lower limit is not clearly defined, and there are no outcrops or uplifts of the strata sufficient to reveal the whole series. The thickness, therefore, cannot be accurately stated.

The entire absence of fossils from these strata, so far as known, and our slight knowledge of the line of separation between them and those of known age, and the impossibility of determining their thickness, render it premature, at least, to assign them to the age of the Trias, and to partition them into groups corresponding to those of the formation in Europe. We may with equal reason call the strata Jurassic, Liassic, Triassic and Permian, or either of them, as Triassic alone. It would be most in accordance with the indications to refer them to the Cretaceous and Carboniferous, the two adjacent formations above and below.

But even if the gypseous strata along the Canadian were proved to be of Triassic age, it does not follow that those along the Upper Missouri, a thousand miles away, are of the same period. According to published reports the strata along the river are Cretaceous, and there is no evidence of the presence of the Trias. Neither is there any evidence of the extension of the Lake Superior sandstone across Wisconsin into Iowa and out to the Missouri, as if the formation occupied an east and west valley in the granite. Such a representation is at variance with published records, and these surely should be regarded in the absence of personal observation. It is hardly necessary to state that the sandstone of Lake Superior has been examined by three separate geological corps,—Messrs. Whitney and Foster with the assistance of Prof. James Hall, by D. D. Owen, and by Sir W. E. Logan of Canada—and after several years of exploration in that region, all arrive at the conclusion that the sandstone is not the New Red, but is the equivalent of the Potsdam sandstone of New York. Prof. James Hall has announced the conclusion also in a notice of a former map by Mr. Marcou.

There is here a disregard of published results and an audacious attempt at generalization which has seldom been equalled. The fact that Mr. Marcou's map is widely circulating in Europe just such American Geology as this, has made it the duty of the science of the country to protest against its being accepted abroad, notwithstanding its publication under the sanction of the Geological Society of France.

ART. XXXIII.—*On New Fossil Corals from North Carolina;* by E. EMMONS. (From a letter to one of the Editors.)

THE fossils which I herewith transmit for your examination occur in Montgomery Co., N. C. I regard them as the oldest organic bodies yet discovered. But that you or your readers may be furnished with facts upon which they may form their opinions, I will state the relations of the masses in which they are found both with the inferior primary series, and the overlying rocks which immediately succeed the beds in which they are found.

1. Talcose slates in connexion with granite or gneissoid granite.

2. Brecciated conglomerate from 300 to 400 feet thick. Parts of this mass are porphyrized.

3. Slaty breccia associated with chert or hornstone.

4. Granular quartz, which is in part vitrified and filled with this fossil and with siliceous concretions, which are about the size of almonds. It is 250–300 feet thick.

5. Slaty quartzite, its fossils much less numerous. It is 40 feet thick.

6. Slaty sandstone without fossils, 50 feet.

7. White quartz, more or less vitrified, filled with fossils and almond-shaped concretions.

8. Jointed granular quartz, similar to that of Berkshire Co., Mass., with only a few fossils.

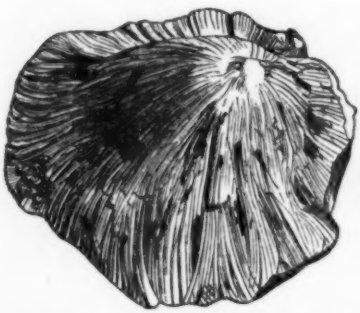
9. Vitrified quartz without fossils, 30 feet thick.

10. Granular quartz, no fossils, thickness great, but undetermined.

11. Overlying these siliceous beds is a clay slate like that so common in Rensselaer and Columbia Cos., N. York. As yet, it has yielded me no fossils. The slate as a whole, remains unchanged, but frequently contains vitrified beds, or silicified ones, the origin of which I do not propose to speak of at this time.

It is evident the fossil is a coral. Among the specimens I think I can recognize two species. The generic name which I have given it is *Palæotrochis*, "*Old Messenger*," the smaller is the *P. minor* (fig. 1), the larger, *P. major*, fig. 2.

2a



2b

Form lenticular and circular, and similar to a double cone, applied base to base; surfaces grooved; grooves somewhat irregular, but extend from the apices to the base or edge. Apex of P. minor provided with a rounded excavation, the opposite with a rounded knob. The description it will be perceived applies to the three smaller figures or *P. minor.*

The reproduction of the coral seems to take place invariably upon the common edge of the double cone. A germ bud, or a young one, appears on the edge of fig. 1*a*. The multiplication of similar buds produces a change of form, as represented in fig. 1*c*, where the edge appears strongly grooved, or double. The middle figure shows the rounded depression, the right hand one, the knob.

It is worthy of notice that as the cones are dissimilar, but meet together at the edge spoken of, this edge becomes the plane of reproduction. I do not know however, but germs are also formed in the grooves, but the coral is constantly undergoing a change of form, by the production of germs upon the edge. The individuals are very numerous, the rock being composed almost entirely of them, intermixed with concretions, for 600 or 700 feet in thickness.

The debris of this fossiliferous sandstone has been worked quite successfully for gold. The metal is contained in ferruginous masses, in the rock which appears to have been an auriferous pyrites. Over $100,000 have been procured by pulverizing and washing this material which also very frequently contains the Palæotrochis.

Albany, September 10, 1856.

Vol. XIII.

*Glyphocrangon antarctica*

*1. Inferior antennæ.*

*2. Superior antennæ.*

Nat. Size.

*Glyptonotus Antarcticus*

ART. XXXIV.—*Description of an Isopod Crustacean from the Antarctic Seas, with Observations on the New South Shetlands;* by JAMES EIGHTS.—With two plates.

[IT is a fact of interest in the geographical distribution of animals, that the largest number of species of the group of Tetradecapods (the 14-footed Crustacea), and those also of the largest size, are found, not in the tropics, but in the temperate and frigid zones. Among *known* species, the ratio for the tropics and extratropics, as I have shown, is 150 : 530, or over three times as many occur in the extra-tropics as in the tropics. In my memoir on the Geographical Distribution of Crustacea, I have stated that out of the 49 recognized genera of Isopods, only 19 occur in the tropics; of 20 genera of Anisopods, only 6 occur in the tropics; and out of the 50 genera of Gammaridea, only 17 contain tropical species. Among the Isopods, the tribe of Idotæidea is especially numerous in cold-water seas; the ratio of extra-tropical to tropical species being 8 : 1; and *two-ninths* of the extra-tropical belonging to the *frigid* zone. Moreover the frigid or subfrigid zone affords the largest of known Idotæidæ, one or more of them three to four inches in length, while the tropical species hardly exceed an inch. The *Glyptonotus* of Eights, from the New South Shetlands, is one of these giant species, the length of his specimen being 3½ inches. It therefore takes the lead among Isopods, and even among all Tetradecapods, and derives thence a peculiar interest. It was described in the 2nd volume of the Albany Institute, and represented by two fine plates engraved by Mr. J. E. Gavit. Through the kindness of Mr. Gavit we are allowed the use of the plates, and therefore here republish the description of Dr. Eights. It is not clear that the genus Glyptonotus is actually distinct from the older one of Idotæa. Yet it will probably be sustained on the ground of the form of the head, the character of the abdomen, and perhaps the distinctive peculiarities of the 6 anterior legs. Part of the characters mentioned in the description are involved in the fact of its belonging to the Tetradecapoda. Still we cite it entire, as published.

The same volume of Transactions of the Albany Institute (pp. 58–69,) contains Remarks by the same author on the New South Shetland Islands, from which we make citations, after giving the description of the Crustacean.—J. D. D.]

GENUS GLYPTONOTUS, *Eights.*

*Animal* composed of a head, thorax, and post-abdomen, constituting in all thirteen distinct segments.

*Head* deeply inserted into the cephalic segment of the thorax. *Eyes* sessile, and finely granulate. *Antennæ* two pairs, placed

one above the other, with an elongate multiarticulated filament. *Mouth* as in the ordinary *Isopods;* mandibles not palpigerous; the two superior foot-jaws expanded into a well defined lower lip, bearing palpi.

*Thorax* separated into seven distinct segments, the three posterior ones biarticulate near their lateral extremities; each segment giving origin to a pair of perfect legs, terminating with a strong and slightly curved nail.

*Post-abdomen*, or tail, divided into five segments, provided with neither styles nor natatory appendages; the under surfaces each supporting a pair of branchial leaflets, longitudinally arranged, and covered by two biarticulated plates attached to the outward edges of the last segment, closing over them much in the manner of an ordinary bivalve shell.

*Species G. Antarctica.*—Animal perfectly symmetrical, ovate, elongate, and depressed. Teguments solid and calcareous. Color, brown sepia. Length, from the insertion of the antennæ, three and a half inches; width, one and three-quarters.

*Head* traversely elliptical, terminating at its lateral and anterior margin obtusely elevated, and arched each way to its centre. Superior surface of the head ornamented with an imperfectly sculptured "fleur-de-lis;" posterior portion obtusely elevated, producing a marginal rim. *Eyes* small, reniform, indigo blue, and placed near the lateral and anterior portion of the head, so deeply impressed in the margin of the shell as to be easily distinguished from beneath. Inferior pair of *antennæ* longer than the superior, corresponding in length to the width of the head, transversely, from spine to spine; articulations four in number; last segment longest, the remaining three gradually diminishing in length as they proceed to the place of insertion; segments triangulate, with angular projections on their surfaces; edges of the angles, and articulating extremities rigidly spined. Terminating filament about the length of the basal articulations, gradually attenuated until it diminishes to a finely pointed apex. Superior *antennæ* half the length of the inferior, three-jointed, and terminating with an attenuated filament whose articulations are indistinct; segments angular, external one much the longest; extremities and angles likewise spined. *Mouth* with the labrum or upper lip hard and massive, resembling in form a reversed heart. The mandibles are without palpi, stout and osseous, tipped with a hard and black enamel. The maxillæ are furnished with the usual palpi. The lower lip, or superior foot-jaws when united, sub-cordate; its palpi five-jointed, snugly embracing the manducatory organs along their base, like a row of ciliated leaflets.

The *thorax* is composed of seven distinct segments, each one being beautifully ornamented on its superior surface by an elon-

gated and sub-conic insculptation, forming a series, whose pointed apices almost unite along the longitudinal dorsal ridge. These segments are finely bordered along their posterior articulating edges by an elevated and continuous marginal rim, extending to the lateral extremities of the shell. The cephalic depression is likewise margined by an obtusely elevated border. Each segment of the thorax gives origin, beneath, to a pair of ponderous angulated legs, composed of the ordinary parts. The three anterior pairs project themselves forward, and are closely compressed upon the inferior surfaces of the three foremost segments; they are monodactyle, with the nails incurved upon the anterior edges of the rather largely inflated penultimate joint. Each joint is furnished at its articulating extremity with rigid spines; the inner edges of the penultimate joint, together with those of the three adjoining, are provided with a double row of tufted ciliæ, disposed diagonally, and much resembling in appearance the arrangement of hairs in an ordinary brush. The four posterior pairs of legs are directed backwards, strongly triangulate, stout and ponderous, terminating by a slightly curved nail; their length is nearly equal, but they gradually increase in thickness as they recede toward the tail. The basal joints are large and inflated; the remainder regularly angulate. The extremities of the articulating joints, and edges of the two inferior angles, are each provided with a series of tufted and rigid spines.

The *post-abdomen* is composed of five segments. The four anterior ones are much smaller than those which constitute the thorax, but greatly resemble them in form, being ornamented on their superior surfaces with similar insculptations, though but slightly defined. Each of these segments is provided beneath with a pair of articulated pedicels, which furnish a support to the bifoliated branchial leaflets. These leaflets are arranged longitudinally one upon the other, and are entirely concealed by the biarticulated plates of the caudal segment; they are suboviate and elongate: the outer ones smaller than those which they cover, and are nearly surrounded by a fringed cilia, most conspicuously developed along their inner margins. The second pair are each supplied with an elongated style, extending almost to the termination of the caudal segment. The terminating segment is large and triangular, giving attachment to the biarticulated plates at a single point on its outer margins near the base, which enables the animal to close them together in a line along its centre beneath. These plates are about the length of the segment, and of a triangulate form, each one having near its termination a small oval articulation. The segment and marginal plates are slightly inflated along their external edges, producing an obtusely elevated border.

The segments constituting the thorax and post-abdomen are supplied by a central, angular, and elongated knob, which, when united, form a prominent dorsal ridge, gradually diminishing in its backward course, and forming a sharp elevated line along the caudal segment, terminating at its extremity in a short and obtusely pointed spine.

This beautiful crustacean furnishes to us another close approximation to the long lost family of the Trilobite. I procured them from the southern shores of the New South Shetland Islands. They inhabit the bottom of the sea, and are only to be obtained when thrown far upon the shores by the immense surges that prevail when the detached glaciers from the land precipitate themselves into the ocean.

### *Extracts from the Remarks of Dr. Eights on the New South Shetlands.*

After landing at several places along the coast and spending some days at Staaten Land, we proceeded to the new South Shetland Islands, which are situated between 61° and 63° of south latitude, and 54° and 63° west longitude. They are formed by an extensive cluster of rocks rising abruptly from the ocean, to a considerable height above its surface. Their true elevation cannot easily be determined, in consequence of the heavy masses of snow which lie over them, concealing them almost entirely from the sight. Some of them however rear their glistening summits to an altitude of about three thousand feet, and when the heavens are free from clouds, imprint a sharp and well defined outline upon the intense blueness of the sky: they are divided everywhere by straits and indented by deep bays, or coves, many of which afford to vessels a comfortable shelter from the rude gales to which these high latitudes are so subject.

The shores of these islands are generally formed by perpendicular cliffs of ice frequently reaching for many miles, and rising from ten feet, to several hundred in height. In many places at their base, the continued action of the water has worn out deep caves with broadly arched roofs, under which the ocean rolls its wave with a subterranean sound that strikes most singularly on the ear; and when sufficiently undermined, extensive portions crack off with an astounding report, creating a tremendous surge in the sea below, which as it rolls over its surface, sweeps everything before it, from the smallest animal that feeds on its shallow bottom, to those of the greatest bulk. Entire skeletons of the whale, fifty or sixty feet in length, are not unfrequently found in elevated situations along the shores many feet above the high water line, and I know of no other cause capable of producing this effect. Whales are very common in this vicinity.

The rocks are composed principally of vertical columns of basalt, resting upon strata of argillaceous conglomerate; the pillars are united in detached groups, having at their bases sloping banks constructed of materials which are constantly accumulating by fragments from above. These groups rise abruptly from the irregularly elevated plains, over whose surface they are here and there scattered, presenting an appearance to the eye not unlike some old castle crumbling into ruin, and when situated upon the sandstone promontories that occasionally jut out into the sea, they tower aloft in solitary grandeur over its foaming waves; sometimes they may be seen piercing the superincumbent snow, powerfully contrasting their deep murky hues with its spotless purity. Ponds of fresh water are now and then found on the plains, but they do not owe their origin to springs, being formed by the melting of the snow.

The rocky shores of these islands are formed of bold craggy eminences standing out into the sea at different distances from each other, from whose bases dangerous reefs not unfrequently lie out for several miles in extent, rendering it necessary for navigators to keep a cautious watch, after making any part of this coast: the intervals between these crags are composed of narrow strips of plain, constructed of coarsely angulated fragments of every variety of size, which at some previous period have fallen from the surrounding hills. They slope gradually down to the water terminating in a fine sandy beach: a few rounded pieces of *granite* are occasionally to be seen lying about, brought unquestionably by the icebergs from their parent hills on some far more southern land, as we saw no rocks of this nature in situ on these islands. In one instance, I obtained a bowlder nearly a foot in diameter from one of these floating hills. The action of the waves has produced little or no effect upon the basalt along this coast, as its angles retain all the acuteness of a recent fracture, but where the conglomerate predominates, the masses are generally rounded.

The color of the basalt is mostly of a greenish black. The prisms have from four to nine sides, most commonly however but six, and are from three to four feet in diameter; their greatest length in an upright position above the subjacent conglomerate is about eighty feet. Their external surfaces are closely applied to each other, though but slightly united, and consequently they are continually falling out by the expansive power of the congealing water among its fissures. When they are exposed to the influence of the atmosphere for any length of time, they are for a small depth of a rusty brown color, owing no doubt to the iron which they contain becoming partially peroxydized: sometimes they are covered by a thin coating of quartz and chalcedony.

Clusters of these columns are occasionally seen reposing on their side in such a manner as to exhibit the surfaces of their base distinctly, which is rough and vesicular. When this is the case they are generally bent, forming quite an arch with the horizon. Where they approach the conglomerate for ten or twelve feet, they lose their columnar structure and assume the appearance of a dark-colored flinty slate, breaking readily into irregular rhombic fragments: this fine variety in descending gradually changes to a greenish color and a much coarser structure, until it passes into a most perfect amygdaloid, the cavities being chiefly filled with quartz, amethyst and chalcedony. Sometimes an interval of about forty or fifty feet occurs between these columns, which space is occupied by the amorphous variety elevated to some considerable height against them; their edges in this case are not at all changed by the contact.

The basis rock of these islands, as far as I could discover, is the conglomerate which underlies the basalt. It is composed most generally of two or three layers, about five feet in thickness each, resting one on the other and dipping to the southeast at an angle of from twelve to twenty degrees. These layers are divided by regular fissures into large rhombic tables, many of which appear to have recently fallen out, and now lie scattered all over the sloping sides of the hills, so that the strata when seen cropping out from beneath the basalt, present a slightly arched row of angular projections of some considerable magnitude and extent.

These strata are chiefly composed of irregular and angular fragments of rock, whose principal ingredient appears to be green earth, arranged into both a granular and slaty structure, and united by an argillaceous cement; the whole mass when moistened by the breath giving out a strong argillaceous odor. The upper portion of this conglomerate for a few feet, is of a dirty green color, and appears to have been formed by the passage of the amygdaloid into this rock, the greenish fragments predominating, and they are united to each other principally by a zeolite of a beautiful light red or orange color, together with some quartz and chalcedony; a few crystals of lime cause it to effervesce slightly in some places. These minerals seem in a great measure to replace the earthy cement. In descending a few feet farther, the green fragments gradually decrease in number and become comparatively rare, the minerals also give place to the cement until the whole mass terminates below in a fine argillaceous substance, with an imperfect slaty structure and a spanish-brown aspect.

This rock being much softer in its nature than the basalt and more affected by decomposing agents, the number of fragments are consequently greater in proportion, and much more finely

pulverised, forming the little soil which supports some of the scattered and scanty patches of vegetation on these islands.

The minerals embraced in this rock are generally confined to its upper part where it unites and passes into the incumbent amygdaloid, and many of them are also in common with that rock. They consist chiefly of quartz, crystalline and amorphous, amethyst, chalcedony, cacholong, agate, red jasper, felspar, zeolite, calcareous spar in rhombic crystals, sulphate of barytes, a minute crystal resembling black spinelle, sulphuret of iron and green carbonate of copper.

The only appearance of an organized remain that I anywhere saw, was a fragment of carbonized wood imbedded in this conglomerate. It was in a vertical position, about two and a half feet in length and four inches in diameter: its color is black, exhibiting a fine ligneous structure, and the concentric circles are distinctly visible on its superior end; it occasionally gives sparks with steel, and effervesces slightly in nitric acid.

There are a number of active volcanoes in the vicinity of these islands, indications of which are daily seen in the pieces of pumice found strewed along the beach. Capt. Weddel saw smoke issuing from the fissures of Bridgeman's island, a few leagues to the northeast. Palmer's land is situated one degree south: what little is known of it, which is only a small portion of its northern shore, contains several. Deception island also one of this group, has boiling springs, and a whitish substance like melted feldspar exudes from some of its fissures. * * * *

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ART. XXXV.—*Description of a large Bowlder in the Drift of Amherst, Massachusetts, with parallel striæ upon four sides;* by Professor EDWARD HITCHCOCK.

IN grading one of the streets in Amherst last year, the surface of a large bowlder, or ledge, in front of the residence of Hon. Edward Dickinson, was brought to light, on which numerous rather fine but distinct striæ were exhibited, whose direction corresponds essentially with that taken by the drift agency in this region, viz., south a few degrees east. This fact led me to suspect the rock to be the top of a ledge: but on probing the earth around, I found it to be a bowlder. The present summer I proposed to my class in Geology, (which is the Junior Class in College), to dig around the specimen, and try to remove at least the top of it to the vicinity of the Geological Cabinet, about half a mile distant, where it might serve as a fine example of striæ to future classes. They promptly engaged in the enterprise, and on digging around the specimen, found it to be of an oblong

shape, the four longest sides being nearly at right angles to each other, while the ends were more irregular. Its medium length was 6½ feet; its breadth, 5½ feet; and its thickness, 2¾ feet. Consequently its weight was about eight tons. It was determined to raise it out of its bed; and when this was done, I was surprised to find the striæ more distinct upon the bottom than anywhere else. They were more minute upon the perpendicular sides than on any other part, though these sides were perhaps the most perfectly smoothed. But on all sides they were essentially parallel, although upon the top there were at least two sets, making a small angle with each other, as is common upon surfaces striated by the drift agency.

I had never met with a bowlder of this description. Its unique character awakened an ambition in the class to remove it entire. I doubted their ability to do this: but young men are strong, and in this case they were very skillful also; for although much of the way is ascending, they went through the work successfully, and without accident; and in a single day they planted the bowlder in front of the Wood's Cabinet on a slope, sustaining the lower end by portions of two large trap columns from Mount Tom, so that the visitor can look beneath and see the striæ there. It stands in the same position as originally, except that the ends are inverted. Deeply engraved upon one end are the words,—"*The Class of* 1857;" that being the year when they graduate.

This rock is a fine-grained hard reddish sandstone, such as occurs on the west face of Mettawampe, (Mt. Toby,) a mountain lying nearly north of Amherst, ten miles distant, and from which the bowlder was undoubtedly derived.

How now shall we explain the parallel striation on four sides of this bowlder? Striated blocks I believe, have generally been regarded as having been frozen into an iceberg, or a glacier, which grated along the surface. But this explains the striæ only on one side. For if the bowlder should happen to have been frozen into a second iceberg, or glacier, how small a chance would there be, that it would be scratched in a parallel direction on a second side. Far less is the probability that a third side would have been striated in the same direction; and almost infinitely less the chance that a fourth side would have experienced a like dressing. Should a bowlder be frozen four times into a mass of ice, how almost certain that the striæ would run in different directions. We must, therefore, give up the idea that this bowlder was scratched in the manner usually assigned.

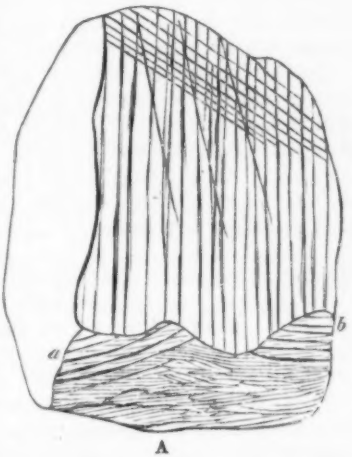
But suppose that when it started from Mettawampe on its southern journey, it were frozen into the bottom of an iceberg. As this grated over the rocky surface, it would soon be smoothed and striated: nor is it strange that in such a manner the erosion

and grooving should be deeper, and the edges less rounded, (as they are) than by what I suppose to have been the subsequent processes.

There is another way in which this striation of the bottom might have been accomplished. It might have been done while yet the bowlder was a part of the ledge from which it was broken. In that case it must have been turned over after starting from its bed.

A third method may be suggested for this work. After the bowlder got mixed up with other fragments, and a strong *vis a tergo*, either aqueous or glacial, was pushing them all forward, so large a block as this might have pressed so heavily upon the surface as to be deeply furrowed.

That a strong force was exerted upon the bowlder to urge it forward, is obvious from a fact respecting the end of it, (A) lying towards the north (now the south end), as shown by the annexed outline. Both ends appear for the most part as if acted upon chiefly by water, being irregularly rounded and smoothed, but not furrowed, except in two places, *a* and *b*. Near the middle, the top, as may be seen, projects a foot or so, and on each side the surface is striated by lines running upwards, as if smaller bowlders had struck against it, and not being able to move it, were forced over it.



A

If a strong current were thus crowding detritus against and over the bowlder, its oblong form would keep its longer axis in the same direction as the stream. Hence the smaller fragments forced against and over it, would smooth the top and the sides in the same direction. They would press most heavily upon the top, and accordingly the striæ are much deeper there than upon the sides, though it should also be recollected that the edge of a stratum is usually harder than its face.

I impute the parallel striation of this bowlder, then, first to its great weight, which caused smaller fragments to slide over it more or less; and secondly, to its oblong form, which kept it nearly in the same position while advancing.

The only striæ on this bowlder not yet described, are a few faint ones running obliquely across the present north end, (the

south end as it lay originally). Most of these I presume are simply the marks of vehicles, which, for the whole spring, passed over this part of the bowlder, and I was surprised to find that they made so slight an impression. I think, however, that among these wagon tracks I can see one or two produced by some other agency; and it is not improbable that during its rough transportation, bowlders might have been forced over it in that direction.

I have regarded the detritus collected along the central part of Amherst, where this bowlder lay, as *Modified Drift:* that is, coarse drift that has been subsequently acted upon, and more or less rounded and sorted by water. Generally the fragments at this place are more rounded and of less size than we see in the coarse drift upon the neighboring hills, and yet the bowlders are considerably larger, though the one now described is much the largest I have seen in our modified drift.

As this bowlder seems to me to be of unusual interest, and is now placed permanently, through the energy and scientific zeal of the class of 1857, where geologists can examine it, I have thought this description might be acceptable to the readers of the Journal. At any rate, it has been the means of qualifying one College Class, as they wander over the world, to examine striated bowlders and ledges.

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## SCIENTIFIC INTELLIGENCE.

### I. CHEMISTRY AND PHYSICS.

1. *On the wave lengths of the most refrangible rays of light in the Interference Spectrum.*—EISENLOHR has contributed a very interesting paper upon the wave lengths of the invisible rays, which he has determined by means of the diffraction spectrum, essentially in the manner employed by Schwerd. The author in the first place describes his method of projecting the phenomena of diffraction upon a screen. A ray of light is introduced horizontally into a dark room by means of a heliostat and allowed to fall upon a narrow vertical slit or other opening placed at a distance of one meter. From 4 to 12 meters behind this slit an achromatic object-glass of 3 meters focal length is placed in a round hole in a board, the plane of which is at right angles to the incident ray. Disks with lattices of different kinds may be fastened immediately in front of the object-glass; a white or transparent screen is placed at a proper distance behind the lens. The image of the slit must be distinctly projected upon this screen before the lattice is fastened in front of the object-glass. In this manner, spectra of extraordinary size and beauty are obtained, particularly when the openings are very narrow and numerous. All the phenomena of diffraction described by Schwerd in his classical work may in this way be represented so that they may be seen by a number of

persons at once. The author considers in the present paper only the phenomena which are seen with a lattice composed of numerous parallel openings. The one employed by him had 1440 parallel lines upon a plane glass 54mm. by 13mm. The spectrum obtained by this lattice could be projected upon a trough filled with a fluorescent liquid, upon paper impregnated with such a liquid, upon a ruler of uranium-glass or upon photographic paper. The spectrum as projected upon a common paper screen exhibited between the two spectra of the first order toward the centre and between the two lines H in the violet, an ill defined dark space. When fluorescent paper was made to receive the spectrum, this dark space became at once sharply defined. The spectrum was longer upon chinin-paper than upon the other fluorescent substances which the author tried, and he confined himself to this in his investigation. The author gives a mathematical investigation of the spectrum as produced by parallel openings, and then makes with the compasses upon the fluorescent paper the requisite measurements of the distances of the points where the first bright spectrum of the diffracted light commences. The wave length is then given by the formula $\lambda = e \sin \psi$, in which $e$ represents the distance between two successive lattice-openings and $\psi$ the angle which the diffracted ray makes with the normal to the surface of the lattice. By placing a violet-colored glass over the opening near the heliostat, the most refrangible end of the spectrum became visible with still greater distinctness and exhibited the sharpest termination: even on common paper the spectrum could be seen and with exactly the same length. When the spectrum as thus produced was received upon a plate of porcelain, no trace of extension could be remarked; the spectrum terminated with the extreme visible rays. The author found as the results of his measurements the following wave lengths in fractions of a millimeter.

Extreme visible red rays $\lambda = 0{\cdot}0007064$.
Extreme visible violet rays $\lambda = 0{\cdot}0003956$.
Most refrangible invisible rays $\lambda = 0{\cdot}0003540$.

*Hence it appears that light from the extreme red to the extreme invisible ray embraces a complete octave.*

With the view of confirming this result the author produced upon chinin-paper a spectrum by means of the same object-glass and a Munich flint glass prism of 45° at a distance of 7 meters. In this manner many of Fraunhofer's and Stokes's lines were seen with great distinctness. The distances of these lines were measured from the line B, and laid off as ordinates upon an axis of abscissas upon which the single distances of the ordinates are expressed by the difference of the corresponding wave lengths. In this manner the author obtained a curve which from the line H to the extreme invisible ray appears to follow the same law as the other portions of the spectrum. Eisenlohr has furthermore found that crown glass does not absorb the invisible rays in such a manner as to shorten the spectrum. This effect is produced by the low dispersive power of the glass for the invisible rays. This is shewn by the fact that a plate of crown glass placed so that the rays constituting the interference spectrum should pass through it before falling upon the chinin-paper does not produce any shortening of the spectrum. By piercing a hole in the screen upon which the spectrum was received where the invisible rays fell the

author separated these and employed them for various experiments on polarization, double refraction and dispersion, which he promises to describe hereafter.—*Pogg. Ann.* xcviii, 353, *June*, 1856.

2. *On the connection between the theorem of the equivalence of heat and work and the relations of permanent gases.*—CLAUSIUS has published some critical remarks upon the paper of Hoppe which has been noticed in this Journal,* his object being mainly to shew that he himself had considered the subject from a different point of view and had arrived at essentially the same results as Hoppe. In a memoir "On a change in the form of the second principal theorem of the mechanical theory of heat," Clausius deduced the equation

$$(1) \qquad Q = U + A.W,$$

in which $Q$ denotes the heat communicated to a body during any change of state, $W$ the external work performed, $A$ the equivalent of heat for the unit of work, and $U$ a quantity of which it may be assumed that it is perfectly determined by the initial and terminal state of the body. In the present notice the author deduces the results of Hoppe from this equation in the following simple manner. For the special case in which the state of the body is given by its temperature $t$ and its volume $v$, $U$ may be considered as a function of these two quantities. When the external work consists only in overcoming a pressure $p$ which opposes the expansion, we have

$$W = \int p\, dv,$$

and we obtain from the previous equation by differentiation,

$$(2) \qquad dQ = \frac{dU}{dt}\, dt + \left(\frac{dM}{dv} + A.p\right) dv.$$

In applying this equation to the more special case of a permanent gas we may express the factors of $dt$ and $dv$ in another manner. The first of these two factors $\frac{dU}{dt}$ is evidently nothing but the specific heat at a constant volume, and we write for it $c$. To express the second factor, the specific heat at a constant pressure, $c'$ must be introduced. According to the laws of Gay Lussac and Mariotte, we have

$$p.v = \frac{p_0 \cdot v_0}{a + t_0}(a + t),$$

in which $a$ represents the inverse volume of the coefficient of expansion. Hence we have

$$dv = \frac{p_0 \cdot v_0}{(a+t_0)p}\, dt.$$

Substituting this value for $dv$ we have

$$dQ = \left[\frac{dU}{dt} + \frac{p_0 \cdot v_0}{(a+t_0)p}\left(\frac{dU}{dv} + A.p\right)\right] dt.$$

The sum in the parenthesis [ ] represents the quantity $c'$, and if we subtract from it the quantity $c = \frac{dU}{dt}$ we have

* Vol. xxi, p. 409.

$$c'-c=\frac{p_0\cdot v_0}{(a+t_0)p}\left(\frac{dU}{dv}+A\cdot p\right),$$

and hence for the second factor the expression

$$\frac{dU}{dv}+A\cdot p=\frac{a+t_0}{p_0\cdot v_0}(c'-c)p.$$

By substituting these expressions in (2), we have

$$(3)\quad dQ=c\,dt+\frac{a+t_0}{p_0\cdot v_0}(c'-c)p\,dv,$$

or if we signify the integration

$$(4)\quad Q=\int c\,dt+\frac{a+t_0}{p_0\cdot v_0}\int(c'-c)p\,dv,$$

which is the sought equation. It is easy to see also that a deviation from the laws of Mariotte and Gay Lussac can be taken into consideration in this investigation as easily as in that of Hoppe.—*Pogg. Ann.* xcviii, 173, *May*, 1856.

3. *On Ozone.*—Andrews has communicated the results of a very elaborate and extended investigation of this subject, which forms an important contribution to our knowledge. The author in the first place repeated the experiments of Baumert, who arrived at the conclusion that ozone is a peroxyd of hydrogen, having the formula $HO_3$. Andrews found that no two experiments led to the same constitution for this peroxyd, and finally discovered that the discrepancy was owing to a small quantity of carbonic acid which, without great care, is always mixed with electrolytic ozone. In Baumert's experiments the increase of weight of the apparatus was always greater than the weight of the ozone as deduced from its chemical action. Andrews found, however, that when the carbonic acid was completely removed these two quantities exactly agreed, so that it is proved that water is not a product of the decomposition of ozone, and therefore that this contains no hydrogen. In like manner it was shewn that no water is produced when ozone is decomposed by heat. The ozone obtained by electrolysis by the action of the electric spark and by the oxydation of phosphorus was found to be identical. Finally, it was found that ozone contained no nitrogen. The author concludes from his investigation that ozone is oxygen in an allotropic modification, and not a compound body as supposed by Schönbein, Williamson, and Baumert.—*Phil. Tr. for* 1855, *quoted in Pogg. Ann.* xcviii, 435, *June*, 1856.

4. *Preparation of Aluminum.*—Brunner has prepared aluminum directly from the fluorid instead of employing cryolite. The fluorid is prepared by dissolving alumina in fluohydric acid, or rather by condensing the acid in the alumina. The fluorid is then reduced by sodium in a hessian crucible, a layer of common salt being placed above the mixture. The yield is not stated.—*Pogg. Ann.* xcviii, 488.

5. *On the conversion of carbonic oxyd into formic acid, and on the preparation of formic from oxalic acid.*—Berthelot has found that when carbonic oxyd is heated in contact with hydrate of potash, formate of potash is produced, the reaction being represented by the equation

$$2CO+KO,HO=C_2HO_3,KO.$$

This observation suggested to the author that formic acid might be produced easily and abundantly by making carbonic oxyd unite with water at the instant of its formation. As oxalic acid is decomposed by heating into carbonic acid, carbonic oxyd and water, it occurred to Berthelot that by heating this acid with some substance which should act by contact, the water and carbonic oxyd would unite to produce formic acid. Glycerin was found to answer the purpose perfectly. The author introduces into a retort of 2 litres capacity, 1 kilogram of syrupy glycerin, 1 kilogram of commercial oxalic acid, and 100–200 grammes of water. A receiver is to be attached and the retort heated gently to 100° C.: carbonic acid is given off, and after from twelve to fifteen hours all the oxalic acid is decomposed, while a little weak formic acid has passed over. Half a liter of water is to be added to the matter in the retort and the whole distilled, water being added from time to time to make up the loss, until 6–7 liters of fluid have distilled over. The distillate then contains almost the whole of the formic acid, while pure glycerin remains in the retort, and may be used again and again. From 3 kilograms of oxalic acid the author obtained 1·051 kilograms of formic acid, which is very nearly the theoretical amount. In this very simple and easy process it is only necessary to proceed slowly and not at too high a temperature, since when the mass reaches 190°–200° pure carbonic oxyd is given off. By this process carbonic oxyd may be prepared in a state of purity, the carbonic acid being first given off. The formic acid is pure and free from oxalic acid.—*Comptes Rendus*, xli, 955 *and* xlii, 447.

[*Note.*—Berthelot's process for preparing formic acid is so easy and elegant that this important substance can hereafter be furnished at a low price and in a state of purity. Its numerous and valuable applications in analytical chemistry will probably be speedily recognized; but it would be well worth while to examine its action in the place of acetic acid in photographic processes.—W. G.]

6. *On the determination of chlorine by titrition.*—With the view of rendering the end of the reaction more distinctly visible, MOHR has suggested the addition of a little neutral chromate of potash to the liquid containing the chlorid. The red color of the chromate of silver makes its appearance as soon as the last trace of chlorine is precipitated as chlorid of silver, and the end of the process is thus very distinct. Levol suggested the employment of phosphate of soda with the same object in view, but a much larger quantity of nitrate of silver solution must be added in this case to produce the yellow color, and the end of the reaction is therefore much less definite. In a second paper, Mohr has extended the method to the determination of many other substances by first converting them into chlorids and then determining the chlorine as above. [The method appears to give in many cases satisfactory results, but it is unfortunately inapplicable in the case of colored solutions. It is to be regretted that the ingenious author does not give a greater number of numerical data to prove the accuracy of the method in the various cases to which he applies it. We would also suggest that the practice of comparing the results obtained by a particular analytical method with theory by the difference should be abandoned, and that in all cases the percentage obtained should be stated.—W. G.]—*Ann. der Chemie und Pharmacie*, xcvii, 335, xcix, 197.

7. *Reduction of aluminum from cryolite.*—Wöhler has found it advantageous in the preparation of aluminum to mix the finely pulverized and well dried cryolite with an equal weight of a mixture of 7 parts of chlorid of sodium and 9 of chlorid of potassium previously melted together and then finely pulverized. The mixture is to be introduced into a hessian crucible in alternate layers with slices of sodium, the separate layers being pressed strongly together. For every 50 grammes of the mixture, 8 or 10 grammes of sodium are to be used. The crucible must be previously strongly dried. It is then to be quickly heated to a white heat in a good furnace. At the moment of reduction a noise is heard and some sodium is volatilized which burns with flame. After this the heat must be kept up for a quarter of an hour to fuse the mass completely, and then allowed to cool. On breaking the crucible, the aluminum is found as a single white regulus, usually with a crystalline surface. In this way about 4 per cent of the weight of the cryolite is obtained, which is only about one-third of the aluminum in the mineral. The aluminum is free from silicon.—*Ann. der Ch. und Pharm.* xcix, 255, *Aug.* 1856.

8. *Researches on the Fluorids.*—Fremy has communicated the results of an elaborate investigation of the compounds of fluorine beginning as it were, *de novo*, from the very elements of the subject, and re-examining many points which have long been considered as settled. The author sums up his conclusions in the following words:—

(1.) Fluohydric acid may be obtained from anhydrous acid in a state of purity by calcining, in a platinum apparatus, the fluohydrate of fluorid of potassium, previously dried. In this state the acid is gaseous at ordinary temperatures; it attacks glass and all silicious substances strongly, contrary to the assertions which have been made on this point of late years.

(2.) All the experiments described in this memoir, confirm the views of the constitution of fluohydric acid now received by all chemists, and shew that this acid really behaves like a hydracid.

(3.) It results from the general study of the fluorids which has been made, that these compounds may be divided into three classes, and that to each of these classes belongs an assemblage of important properties. The first class comprises the anhydrous fluorids which are comparable to the chlorids; the second the hydrated fluorids which behave, in all their reactions, like fluohydrates; in the third class we find the fluohydrates of fluorids which are true acid salts.

(4.) The anhydrous fluorids are remarkable for their stability; the hydrated fluorids are, on the contrary, unstable, and sometimes decompose even when they are dried in vacuo, disengaging fluohydric acid and leaving as a residue an oxyfluorid or oxyd.

(4.) The fluorids have a great tendency to unite to form double fluorids; this property belongs even to the insoluble fluorids. Thus these last compounds must never be prepared by double decomposition, because they always retain, in their state of double salt, a part of the soluble salt which has been employed in their preparation.

(6.) Hydrogen does not decompose all the fluorids by the aid of heat; thus it does not act on the fluorids of calcium: but it reduces with the greatest facility, the fluorids of lead, tin, &c. The reduction of the metallic fluorids by hydrogen, like those of lead and tin, which resist the action

of carbon, appears to demonstrate, in a positive manner that these compounds do not contain oxygen, and are really binary substances.

(7.) All fluorids, even those of potassium, sodium and calcium, are rapidly decomposed by the vapor of water.

(8.) Oxygen and chlorine, at a strong heat, decompose fluorid of calcium, and set free a gas which appears to be fluorine.

(9.) The vapor of sulphur does not act on fluorid of calcium, but this body is decomposed completely by the vapor of sulphid of carbon; there is formed in this case sulphid of calcium, and probably fluorid of carbon; the presence of silicious matters facilitates the reaction.

(10.) The analyses of the principal fluorids which are cited in this memoir, as those of the fluorids of potassium, sodium, calcium, tin, lead and silver, show that the equivalent of fluorine, determined by Berzelius, is exact.

(11.) All the anhydrous fluorids, when fused, may be decomposed by the galvanic battery, and disengage a gas which appears to be the radical of the fluorids.—*Ann. de Chimie et de Physique*, xlvii, 5, *May*, 1856.

9. *On two new methods of producing Urea artificially.*—Natanson has succeeded in showing that carbamid and urea are identical. When carbonate of ethyl and ammonia are heated together in a sealed tube to 100° C., only urethan is formed; but at 180°, the urethan is converted, by the excess of ammonia into urea. When phosgene gas and ammonia are brought into contact, a white saline mass is formed, first studied in 1838, by Regnault, and which behaves like a mixture of carbamid and sal-ammoniac. Regnault did not succeed in separating the two substances or in proving that urea was present. This Natanson has done, and it is therefore proved that urea and carbamid are identical.

10. *On Acetylamin.*—Natanson has more fully described this very interesting alkaloid, which he obtains by distilling the hydrated oxyd of acetyl-ammonium, which at a high temperature is decomposed into acetylamin and water, according to the equation

$$\left.\begin{matrix} C_4H_3 \\ H \\ H \\ H \end{matrix}\right\} NO, HO = \left.\begin{matrix} C_4H_3 \\ H \\ H \end{matrix}\right\} + 2HO.$$

The decomposition begins at 150° C.; the acetylamin distils over at 220°, as a slightly yellow liquid of peculiar ammoniacal persistent smell. It boils at 218°, and is soluble in all proportions in water and alcohol, but not in ether. The density of its vapor was found to be 1·522=4 vols. By union with acids it forms salts of acetyl-ammonium, from which it is very remarkable that potash precipitates the hydrate of the oxyd of acetyl-ammonium and not acetylamin. The author describes an ethyl acetylamin and an anilin acetylamin—*Ann. der Chemie und Pharmacie*, xcviii, 287, 291, *June*, 1856. W. G.

11. *The Manufacture of Malleable Iron and Steel without Fuel*, (Proc. Brit. Assoc., August, 1856; Ath. No. 1504.)—At a meeting of the British Association for the Advancement of Science, held at Cheltenham in August last, Mr. H. Bessemer read a highly interesting and important paper on the manufacture of malleable iron and steel without fuel. For two years

Mr. Bessemer has devoted his attention almost exclusively to the subject. Preliminary trials were made on from ten to twenty pounds of iron, and "although the process was fraught with considerable difficulty, it exhibited such unmistakeable signs of success," Mr. Bessemer observed, "as to induce me at once to put up an apparatus, capable of converting about seven hundred of crude pig iron into malleable iron in thirty minutes."

"I set out with the assumption that crude iron contains about five per cent. of carbon; that carbon cannot exist at a white heat in the presence of oxygen without uniting therewith and producing combustion; that such combustion would proceed with a rapidity dependent on the amount of surface of carbon exposed: and, lastly, that the temperature which the metal would acquire would be also dependent on the rapidity with which the oxygen and carbon were made to combine, and consequently that it was only necessary to bring the oxygen and carbon together in such a manner that a vast surface should be exposed to their mutual action, in order to produce a temperature hitherto unattainable in our largest furnaces.

With a view of testing practically this theory, I constructed a cylindrical vessel of three feet in diameter and five feet in height, somewhat like an ordinary cupola furnace, the interior of which is lined with fire bricks; and at about two inches from the bottom of it I insert five tuyère pipes, the nozzles of which are formed of well-burned fire clay, the orifice of each tuyère being about three-eights of an inch in diameter; they are so put into the brick lining (from the outer side) as to admit of their removal and renewal in a few minutes when they are worn out. At one side of the vessel, about half way up from the bottom, there is a hole made for running in the crude metal, and on the opposite side there is a tap-hole stopped with loam, by means of which the iron is run out at the end of the process. In practice this converting vessel may be made of any convenient size, but I prefer that it should not hold less than one, or more than five tons, of fluid iron at each charge. The vessel should be placed so near to the discharge hole of the blast furnace as to allow the iron to flow along a gutter into it; a small blast cylinder will be required capable of compressing air to about 8lb. or 10lb. to the square inch.

A communication having been made between it and the tuyères before named, the converting vessel will be in a condition to commence work; it will, however, on the occasion of its first being used after relining with fire-bricks, be necessary to make a fire in the interior with a few baskets of coke, so as to dry the brickwork, and heat up the vessel for the first operation, after which the fire is to be all carefully raked out at the tapping-hole, which is again to be made good with loam. The vessel will then be in readiness to commence work, and may be so continued, without any use of fuel, until the brick lining in the course of time, becomes worn away, and a new lining is required. I have before mentioned that the tuyères are situated nearly close to the bottom of the vessel; the fluid metal will therefore rise some eighteen inches or two feet above them.

It is therefore necessary, in order to prevent the metal from entering the tuyère holes, to turn on the blast before allowing the fluid crude iron to run into the vessel from the blast furnace. This having been done, and the fluid iron run in, a rapid boiling up of the metal will be heard

going on within the vessel, the metal being tossed violently about and dashed from side to side, shaking the vessel by the force with which it moves, from the throat of the converting vessel. Flame will then immediately issue, accompanied by a few bright sparks. This state of things will continue for about fifteen or twenty minutes, during which time the oxygen in the atmospheric air combines with the carbon contained in the iron, producing carbonic acid gas, and at the same time evolving a powerful heat.

Now, as this heat is generated in the interior of, and is diffusive in innumerable fiery bubbles through the whole fluid mass, the metal absorbs the greater part of it, and its temperature becomes immensely increased, and by the expiration of the fifteen or twenty minutes before-named, that part of the carbon which appears mechanically mixed and diffused through the crude iron has been entirely consumed. The temperature, however, is so high that the chemically combined carbon now begins to separate from the metal, as is at once indicated by an immense increase in the volume of flame rushing out of the throat of the vessel. The metal in the vessel now rises several inches above its natural level, and a light frothy slag makes its appearance, and is thrown out in large foam-like masses. This violent eruption of cinder generally lasts about five or six minutes, all further appearance of it ceases, when a steady and powerful flame replaces the shower of sparks and cinder which always accompanies the boil.

The rapid union of carbon and oxygen which thus takes place adds still further to the temperature of the metal, while the diminished quantity of carbon present allows a part of the oxygen to combine with the iron, which undergoes combustion and is converted into an oxyd. At the excessive temperature that the metal has now acquired, the oxyd as soon as formed undergoes fusion, and forms a powerful solvent of those earthy bases that are associated with the iron. The violent ebullition which is going on mixes most intimately the scoria and the metal, every part of which is thus brought in contact with the fluid oxyd, which will thus wash and cleanse the metal most thoroughly from the silica and other earthy bases which are combined with crude iron, while the sulphur and other volatile matters which cling so tenaciously to iron at ordinary temperatures, are driven off, the sulphur combining with the oxygen and forming sulphurous acid gas.

The loss in weight of crude iron, during its conversion into an ingot of malleable iron, was found on a mean of four experiments to be 12½ per cent, to which will have to be added the loss of metal in the finishing rolls. This will make the entire loss probably not less than 18 per cent, instead of about 28 per cent., which is the loss on the present system. A large portion of this metal, however, is recoverable by treating with carbonaceous gases the rich oxyd thrown out of the furnace during the boil. These slags are found to contain innumerable small grains of metallic iron, which are mechanically held in suspension in the slags, and may be easily recovered. I have before mentioned that after the boil has taken place a steady and powerful flame succeeds, which continues without any change for about ten minutes, when it rapidly falls off.

As soon as this diminution of flame is apparent, the workman well know that the process is completed, and that the crude iron has been

converted into pure malleable iron, which he will form into ingots of any suitable size and shape by simply opening the tap-hole of the converting vessel and allowing the fluid malleable iron to flow into the iron ingot-moulds placed there to receive it. The masses of iron thus formed will be perfectly free from any admixture of cinder, oxyd or other extraneous matters, and will be far more pure, and in a forwarder state of manufacture than a pile formed by ordinary puddle bars. And thus it will be seen that by a single process, requiring no manipulation or particular skill, and with only one workman, from three to five tons of crude iron passes into the condition of several piles of malleable iron in from thirty to thirty-five minutes, with the expenditure of about one-third part the blast now used in a finery furnace with an equal charge of iron, and with the consumption of no other fuel than is contained in the crude iron.

To those who are best acquainted with the nature of fluid iron it may be a matter of surprise that a blast of cold air forced into melted crude iron is capable of raising its temperature to such a degree as to retain it in a perfect state of fluidity after it has lost all its carbon, and is in the condition of malleable iron, which in the highest heat of our forges only becomes softened into a pasty mass. But such is the excessive temperature that I am enabled to arrive at with a properly shaped converting vessel and a judicious distribution of the blast, that I am able not only to retain the fluidity of the metal, but to create so much surplus heat as to re-melt the crop ends, ingot runners, and other scrap that is made throughout the process, and thus bring them without the labor or fuel into ingots of a quality equal to the rest of the charge of new metal. For this purpose a small arched chamber is formed immediately over the throat of the converting vessel, somewhat like the tunnel-head of the blast furnace. This chamber has two or more openings on the sides of it, and its floor is made to slope downwards to the throat.

As soon as a charge of fluid malleable iron has been drawn off from the connecting vessel, the workman will take the scrap intended to be worked into the next charge and proceed to introduce the several pieces into the small chamber, piling them up around the opening of the throat. When this is done he will run in his charge of crude metal, and again commence the process. By the time the boil commences the bar ends or other scrap will have acquired a white heat, and by the time it is over most of them will have been melted and run down into the charge. Any pieces, however, that remain, may then be pushed in by the workman, and by the time the process is completed they will all be melted, and ultimately combined with the rest of the charge, so that all scrap-iron, whether cast or malleable, may thus be used up without any loss or expense.

As an example of the power that iron has of generating heat in this process, I may mention a circumstance that occurred to me during my experiments: I was trying how small a set of tuyères could be used, but the size chosen proved to be too small, and after blowing into the metal for one hour and three-quarters I could not get up heat enough with them to bring on the boil. The experiment was therefore discontinued, during which time two-thirds of the metal solidified, and the rest was run off. A larger set of tuyère pipes were then put in, and a fresh charge of fluid

iron run into the vessel, which had the effect of entirely remelting the former charge, and when the whole was tapped out, it exhibited, as usual, that intense and dazzling brightness peculiar to the electric light.

To persons conversant with the manufacture of iron it will be at once apparent that the ingots of malleable metal which I have described will have no hard or steely parts, such as is found in puddled iron, requiring a great amount of rolling to bend them with the general mass, nor will such ingots require an excess of rolling to expel cinder from the interior of the mass, since none can exist in the ingot, which is pure and perfectly homogeneous throughout, and hence requires only as much rolling as is necessary for the development of fibre; it therefore follows that, instead of forming a merchant bar or rail by the union of a number of separate pieces welded together, it will be far more simple and less expensive to make several bars or rails from a single ingot; doubtless this would have been done long ago had not the whole process been limited by the size of the ball which the puddler could make.

The facility which the new process affords of making large masses will enable the manufacturer to produce bars that on the old mode of working it was impossible to obtain; while, at the same time, it admits of the use of some powerful machinery whereby a great deal of labor will be saved, and the process be greatly expedited. I merely mention this fact in passing, as it is not my intention at the present moment to enter upon any details of the improvements I have made in this department of the manufacture, because the patents which I have obtained for them are not yet specified.

Before, however, dismissing this branch of the subject, I wish to call the attention of the meeting to some of the peculiarities which distinguish cast-steel from all other forms of iron, namely, the perfect homogeneous character of the metal, the entire absence of sand-cracks or flaws, and its greater cohesive force and elasticity as compared with the blister-steel from which it is made, qualities which it derives solely from its fusion and formation into ingots, all of which qualities malleable iron acquires in like manner by its fusion and formation into ingots in the new process. Nor must it be forgotten that no amount of rolling will give to blister-steel (although formed of rolled bars) the same homogeneous character that cast-steel acquires by a mere extension of the ingot to some ten or twelve times its original length.

One of the most important facts connected with the new system of manufacturing malleable iron is that all the iron so produced will be of that quality known as charcoal iron, not that any charcoal is used in its manufacture, but because the whole of the processes following the smelting of it are conducted entirely without contact with, or the use of any mineral fuel; the iron resulting therefrom will, in consequence, be perfectly free from those injurious properties which that description of fuel never fails to impart to iron that is brought under its influence. At the same time, this system of manufacturing malleable iron, offers extraordinary facility for making large shafts, cranks, and other heavy masses; it will be obvious that any weight of metal that can be founded in ordinary cast-iron by the means at present at our disposal may also be founded in molten malleable iron, and be wrought into the forms and

shapes required, provided that we increase the size and power of our machinery to the extent necessary to deal with such large masses of metal. A few minutes' reflection will show the great anomaly presented by the scale on which the consecutive processes of iron-making are at present carried on. The little furnaces originally used for smelting ore have from time to time increased in size, until they have assumed colossal proportions, and are made to operate on 200 or 300 tons of materials at a time, giving out ten tons of fluid metal at a single run. The manufacturer has thus gone on increasing the size of his smelting furnaces, and adapting to their use the blast apparatus of the requisite proportions, and has by this means lessened the cost of production in every way; his large furnaces require a great deal less labor to produce a given weight of iron than would have been required to produce it with a dozen furnaces, and in like manner he diminishes his cost of fuel-blast and repairs, while he insures a uniformity in the result that never could have been arrived at by the use of a multiplicity of small furnaces. While the manufacturer has shown himself fully alive to these advantages, he has still been under the necessity of leaving the succeeding operations to be carried out on a scale wholly at variance with the principles he has found so advantageous in the smelting department. It is true that hitherto no better method was known than the puddling process, in which from 400 to 500 weight of iron is all that can be operated upon at a time, and even this small quantity is divided into homœopathic doses of some seventy or eighty pounds, each of which is moulded and fashioned by human labor, carefully watched and tended in the furnace, and removed therefrom one at a time, to be carefully manipulated and squeezed into form.

When we consider the vast extent of the manufacture, and the gigantic scale on which the early stages of the process are conducted, it is astonishing that no effort should have been made to raise the after-processes somewhat nearer to a level commensurate with the preceding ones, and thus rescue the trade from the trammels which have so long surrounded it.

Before concluding these remarks I beg to call your attention to an important fact connected with the new process, which affords peculiar facilities for the manufacture of cast-steel.

At that stage of the process immediately following the boil, the whole of the crude iron has passed into the condition of cast-steel of ordinary quality; by the continuation of the process the steel so produced gradually loses its small remaining portion of carbon, and passes successively from hard to soft steel, and from soft steel to steely iron, and eventually to very soft iron; hence, at a certain period of the process, any quality of metal may be obtained; there is one in particular which, by way of distinction, I call semi-steel, being in hardness about mid-way between ordinary cast-steel and soft malleable iron. This metal possesses the advantage of much greater tensile strength than soft iron; it is also more elastic, and does not readily take a permanent set, while it is much harder, and is not worn or indented so easily as soft iron; at the same time it is not so brittle or hard to work as ordinary cast-steel. These qualities render it eminently well adapted to purposes where lightness and strength are specially required, or where there is much wear, as in the case of

railway bars, which from their softness and lamellar texture soon become destroyed. The cost of semi-steel will be a fraction less than iron, because the loss of metal that takes place by oxydation in the converting vessel is about 2½ per cent. less than it is with iron; but, it is a little more difficult to roll, its cost per ton may fairly be considered to be the same as iron; but, as its tensile strength is some thirty or forty per cent. greater than bar-iron, it follows that for most purposes a much less weight of metal may be used, so that, taken in that way, the semi-steel will form a much cheaper metal than any that we are at present acquainted with.

In conclusion, allow me to observe that the facts which I have had the honor of bringing before the meeting have not been elicited from mere laboratory experiments, but have been the result of working on a scale nearly twice as great as is pursued in our largest iron works, the experimental apparatus doing seven cwt. in thirty minutes, while the ordinary puddling furnace makes only 4½ cwt. in two hours, which is made into six separate balls, while the ingots or blooms are smooth even prisms, ten inches square by thirty inches in length, weighing about equal to ten ordinary puddle balls."

12. *On some Dichromatic Phenomena among Solutions, and the means of representing them;* by Dr. GLADSTONE, (Proc. Brit. Assoc. August, 1856; Ath. No. 1505.)—This paper was an extension of Sir John Herschel's observations on dichromatism, that property whereby certain bodies appear of a different color according to the quantity seen through. It depends generally on the less rapid absorption of the red ray as it penetrates a substance. A dichromatic solution was examined by placing it in a wedge-shaped glass-trough, held in such a position that a slit in the window-shutter was seen traversing the varying thicknesses of the liquid. The diversely colored line of light thus produced was analyzed by a prism; and the resulting spectrum was represented in a diagram by means of colored chalks on black paper, the true position of the apparent colors being determined by the fixed lines of the spectrum. In this way the citrate and comenamate of iron, sulphate of indigo, litmus in various conditions, cochineal, and chromium, and cobalt salts were examined and represented. Among the more notable results were the following:—A base, such as chromic oxyd, produces very nearly the same spectral image with whatever acid it may be combined, although the salts may appear very different in color to the unaided eye. Citrate of iron appears green, brown, or red, according to the quantity seen through. It transmits the red ray most easily, then the orange, then the green, which covers the space usually occupied by the yellow; it cut off entirely the more refrangible half of the spectrum. Neutral litmus appears blue or red, according to the strength or depth of the solution. Alkalies cause a great development of the blue ray; acids cause a like increase of the orange, while the minimum of luminosity is altered to a position much nearer the blue. Boracic acid causes a development of the violet. Alkaline litmus was exhibited so strong that it appeared red, and slightly acid litmus so dilute that it looked bluish purple; indeed, on account of the easy transmissibility of the orange ray through an acid solution, the apparent paradox was maintained that a large amount of alkaline litmus is of a purer red than acid litmus itself. Another kind of dichromatism was examined,

dependent not on the actual quantity of colored material, but on the relative proportion of the solvent. Diagrams of the changing appearances of sulphocyanid of iron, of chlorid of copper, and of chlorid of cobalt were exhibited.

13. *On several new Methods of detecting Strychnia and Brucia;* Experiments on Animals with Strychnia, and probable reasons for non-detection of Strychnia in certain cases; and a new method of instituting post-mortem researches in Strychnia; by Mr. T. HORSLEY, (Proc. Brit. Assoc., Aug. 1856; Ath. No. 1503.)—In the first lecture, Mr. Horsley observed that the circumstances attending Palmer's trial induced him to make a series of experiments on the subject, and he tried the effects of a precipitant formed of one part of bichromate of potash dissolved in fourteen parts of water to which was afterwards added two parts in bulk of strong sulphuric acid. This being tried upon a solution of strychnine, the bulk was entirely precipitated in the form of a beautiful golden-colored and insoluble chromate. The experiment, as performed by Mr. Horsley, was very interesting, and scarcely a trace of bitterness was left in the filtered liquor. He did not claim to have originated this discovery of the use of a chromic salt and an acid liquor; but the point to which he called attention was the essential difference in the mode of application, and he maintained that it was as much out of the power of any human being to define the limit of sensibility which he had attained, as it would be to count the sands or to measure the drops of the ocean. Taking thirty drops of a solution of strychnia containing half a grain, he diluted it with four drams of water. He then dropped in six drops of a solution of bichromate of potash, when crystals immediately formed, and decomposition was complete. Splitting up the half grain of strychnia into millions of atoms of minute crystals, he said that each of these atoms, if they could be separated, would as effectually demonstrate the chemical characteristics of strychnia as though he had operated with a pound weight of the same. He then showed the chemical reaction with those crystals. Dropping a drop of liquor containing the chromate of strychnia into an evaporating dish and shaking it together, he added a drop or two of strong sulphuric acid, and showed the effect as previously noted. He next showed the discoloration produced in chromate of strychnia and chromate of brucia by sulphuric acid, the former being changed to a deep purple and then to a violet and red. It had been asserted since the trial of Palmer that the non-detection of strychnine in the body of John Parsons Cook was owing to the antimony taken by the deceased having somewhat interfered with the tests. Such a supposition was, in his (Mr. Horsley's) opinion, absurd. Nothing, he considered, could more incontestably disprove the fallacy than either of two new tests which he then performed. These he considered double tests, because they had first the obtainment of a peculiar crystalline compound of strychnine, which was afterwards made to develop the characteristic effects by which strychnine is recognized. Mr. Horsley next related a series of experiments which he had made on animals with strychnine, and entered into the probable reasons for its non-detection in certain cases, although (as he had just shown before) a method of detecting infinitesimal quantities of strychnia by tests. Having procured three rats at seven o'clock P. M., he (assisted by Dr.

Wright) gave each rat a quarter of a grain of powdered strychnia, and two hours afterwards a quarter and half a grain more to one of the three. Next morning at four o'clock they were all alive, and had eaten food (bread and milk) in the night, but at seven, or a few minutes after, they were all dead. The longest liver was one of the rats that had had only a quarter of a grain. In about three hours afterwards he applied the usual test, but could not detect the least indication of strychnine in the precipitate. There was, moreover, a total absence of bitterness in all the liquor. He tried every part of the bodies of the rats with the like results. What, then, became of the strychniue? Had it been decomposed in the organism, and its nature changed, as Baron Liebig intimated? As to the non-detection of strychnine, he thought it not improbable that the strychnine might have become imbibed into the albumen or other solid matter, and so abstracted from the fluid, forming by coagulation (say, for instance, in the blood) a more or less insoluble albuminate. This idea had occurred to him from noticing the coagulation of the glairy white of egg with strychnine, and the fact of his not recovering the full quantity of the alkaloid whenever he had introduced it. At any rate, it merited consideration. In his second experiment he administered three-quarters of a grain of strychnia to a wild rat, but the animal evinced little of the effects of the poison, and it was purposely killed after five days. His third experiment was with two grains of strychnia, administered as a pill wrapped up in blotting-paper, to a dog—a full-sized terrier. It was apparently quite well for five hours, when the operator went to bed, but was found dead next morning, but lying apparently in the most natural position for a dog asleep. When taken up blood flowed freely from its mouth. On opening the animal (continued Mr. Horsley) I found the right ventricle of the heart empty of blood, whilst the left was full, some of the blood being liquid and some clotted. The stomach was carefully secured at both its orifices, and detached. On making an incision, I was surprised at not seeing the paper in which I had wrapped the pill, naturally expecting it would have been reduced to a pulp by the fluid of the stomach. I, therefore, sought for it, and lo! here it is, in precisely the same condition as when introduced into the gullet of the dog, and containing nearly all the strychnine. I have been afraid to disturb it until I had exhibited it to you, and now I will weigh the contents, and ascertain how much has been absorbed or dissolved. This experiment is important as showing the small quantity of strychnia necessary to destroy life; and, had I not been thus particular to search for the paper envelope, it might, possibly, have led to a fallacy, as I must have used an acid, and that would have dissolved out the strychnia, and the inference would have been that it was obtained from the contents of the stomach, whereas it had never been diffused. In this case, also, none of the absorbed strychnia was detectable in the blood or any part of the animal, although the greatest care was observed in making the experiments. The lecturer, who was listened to throughout with great attention, added that he had made further experiments, which he thought proved that it was highly probable a more or less insoluble compound of organic or animal matter with strychnia is found.

## II. GEOLOGY.

1. *On the Spongeous Origin of the Siliceous Bodies of the Chalk Formation;* by J. S. Bowerbank, (Proc. Brit. Assoc., August, 1856; Ath. No. 1505.)—The author attributes the whole of the numerous strata of nodular and tabular flints to vast quantities of spongeous bodies that existed in the seas of those remote periods. The elective attraction of the animal matter of the sponges inducing the deposit of the silex, which in the first instance is always in the form of a thin film surrounding the skeleton of the sponge, and from which successive crops of calcedonic crystals proceed, until the solidification of the whole is effected. The tabular form is accounted for on the presumption that the sponges originating the deposit grew on a more consolidated bottom than the tuberous ones, and that they therefore developed themselves in a lateral direction instead of in an erect position, and on approximating each other were cemented together, and thus formed continuous beds of considerable extent; and the author illustrated this portion of his subject by the production of four recent sponges of the same species, which, by being placed in contact while in the living state, became firmly united to each other within eighteen hours, ultimately forming one sponge. The occurrence of the shells of Echinoderms and of bivalve shells filled with flint was accounted for on the same principle; and the author produced recent bivalve shells, in a closed condition, completely filled with recent sponges of the same species as the sponges of commerce. The loose specimens of fossil sponges included in the Wiltshire flints were explained on the principle that, although sponges of the same species readily adhere to each other when placed in contact, those of different species never unite, however closely they may be pressed together. The author concluded his paper by applying the same principles to the siliceous deposits of the whole of the geological formations which were of aqueous origin.

2. *On some Palæozoic Starfishes, compared with Living Forms;* by J. W. Salter, (Proc. Brit. Assoc., August, 1856; Ath. No. 1505.)—The object of the communication was chiefly to exhibit some new forms of Asteriadæ, from the Upper Silurian rocks, which have all the aspect of Ophiuridæ, but are essentially distinguished by the number of ossicles which go to form a single segment of the arms,—the lower surface showing the characteristic double row of ambulacral bones (in this case flat plates,) and the upper being composed either of two or more rows of plates, while the Ophiuridæ have a single plate above, and one below. There is, however, the closest similarity to the latter family in the length of the arms and the restriction of the disc (*Protaster*, Forbes), as well as in the great length of the spines on the margin (*Palæocoma*), while in the pentagonal form and simply plated integument of another genus (*Palasterina*), there is a much nearer approach made to the Asteriscus or *Palmipes roseus* than to any other type of living starfish. It is to this group that the fossils are supposed to belong; and to some of the species which have the disc little developed, or quite absent, there is a strong resemblance in a Lower Silurian form originally described by Forbes as *Uraster*, but which better specimens show to have had but two rows of suckers, and the avenues bordered by very large plates. The name Pa-

læaster is proposed for this group, which is represented by four or five species. The genera are;—*Palæaster* (Salter), without disc, avenues deep, Upper and Lower Silurian, 4 species; *Palasterina* (ib.), pentagonal, disc moderate, Up. Sil., 1 species; *Palæocoma* (ib.), no disc, avenues very shallow, Up. Sil., 4 species; *Protaster* (Forbes), disc small, arms long, extended, Upper (and Lower) Sil., 4 species. There appear to be no other forms yet described.

3. *On the Physical Structure of the Earth;* by Prof. HENNESSY, (Proc. Brit. Assoc.; Ath. No. 1504.)—After some preliminary observations as to the impossibility of accounting for the earth's figure, without supposing it to have been once a fused mass, the exterior of which has cooled into a solid crust, the process of solidification of the fluid was described. The influence of the connexion and circulation of the particles in a heterogeneous fluid was shown to be different from what would take place in a homogeneous fluid such as usually come under our notice. As the primitive fluid mass of the earth would consist of strata increasing in density from the surface towards the centre, its refrigeration would be that of a heterogeneous fluid, and the process of circulation would be less energetic in going from its surface towards its centre. Thus, the earth would ultimately consist of a fluid nucleus inclosed in a spheroidal shell. The increase in thickness of this shell would take place by the solidification of each of the surface strata of the nucleus in succession. If the matter composing the interior of the earth is subjected to the same physical laws as the material of the solid crust coming under our notice, the change of state in the fluid must be accompanied by a diminution of its volume. The contrary hypothesis has been hitherto always assumed in mathematical investigations relative to the form and structure of the earth. The erroneous supposition that the particles of the primitive fluid retained the same positions after the mass had advanced in the process of solidification as they had before the process commenced, had been tacitly or openly assumed in all such inquiries until it was formally rejected by the author, who proposed to assume for the fluid similar properties to those exhibited by the fusion and solidification of such portions of the solidified crust as are accessible to observation. The results to which the improved hypothesis has led show that it fundamentally affects the whole question, not only of the shape and internal structure of the earth, but also of the various actions and reactions taking place between the fluid nucleus and the solid shell. If the process of solidification took place without change of volume in the congelation of the fluid, the strata of the shell would possess the same forms as those of the primitive fluid, and their oblateness would diminish in going from the outer to the inner surface. If the fluid contracts in volume on passing to the solid state, the remaining fluid will tend to assume a more and more oblate figure after the formation of each stratum of the shell. The law of density of the nucleus will not be the same as that of the primitive fluid, but will vary more slowly, and the mass will thus tend towards a state of homogeneity as the radius of the nucleus diminishes by the gradual thickening of the shell. The surface of the nucleus, and consequently the inner surface of the shell, will thus tend to become more oblate after each successive stratum added to the shell by congelation from the nucleus.

This result, combined with another obtained by Mr. Hopkins, proves that so great pressure and friction exist at the surface of contact of the shell and nucleus as to cause both to rotate together nearly as one solid mass. Other grounds for believing in the existence of the great pressure exercised by the nucleus at the surface of the shell were adduced. If the density of the fluid strata were due to the pressures they support, and if the earth solidified without any change of state in the solidifying fluid, the pressure against the inner surface of the shell would be that due to the density of the surface stratum of the nucleus, and would, therefore, rapidly increase with the thickness of the shell. Contraction in volume of the fluid on entering the solid state would diminish this pressure, but yet it may continue to be very considerable, as the co-efficient of contraction would always approach towards unity. The phenomena of the solidification of lava and of volcanic bombs were referred to in illustration of these views, and their application was then shown to some of the greatest questions of geology. The relations of symmetry which the researches of M. Elie de Beaumont seem to establish between the great lines of elevation which traverse the surface of the earth appear to Prof. Hennessy far more simply and satisfactorily explained by the expansive tendency of the nucleus which produces the great pressure against the shell than by the collapse and subsidences of the latter. The direction of the forces which would tend to produce a rupture from the purely elevatory action of the pressure referred to would be far more favorable to symmetry than if the shell were undergoing a distortion of shape from collapsing inwards. The nearly spherical shape of the shell would also greatly increase its resistance to forces acting perpendicularly to its surface, so as to cause it to subside, while the action of elevatory forces would not be resisted in the same manner.

4. *On the Great Pterygotus (Seraphim) of Scotland, and other Species;* by Mr. J. W. Salter, (Proc. Brit. Assoc., August, 1856; Ath. No. 1504.) This paper was in some measure a continuation of one published in the *Quarterly Geological Journal* for 1855, describing some new and large Crustacean forms from the uppermost Silurian rocks of the south of Scotland. They were described under the name of Himanthopterus, and were supposed to differ from the published fragments of the great Pterygotus by the lateral position of the large simple eyes. In the general shape of the body, however, the terminal joints and tail, in the want of appendages to the abdomen, as well as in the form and number of the swimming feet, mandibles, maxillæ and antennæ, there was found to be on further examination the closest resemblance between Himanthopterus and the great Pterygotus. And the resemblance has been carried still further by the favorable collocation of all the known specimens from the Scotch collections which have furnished us with nearly all the portions, and also with the head, which we now find to be exactly like that of Himanthopterus, having *lateral*, not *subcentral*, eyes, as represented by other authors. The two genera are therefore identical, and the group, as now constituted, includes a number both of small and moderate-sized crustacea, along with some which were far larger than any living species, and which certainly attained a length of six or eight feet! The collections made by the Scotch geologists, in connection with other specimens

obtained by Mr. Banks, of Kington, and Messrs. Lightbody & Cockis, of Ludlow, show us that Pterygotus was an elongate crustacean, with a comparatively small head and sessile compound eyes, few appendages, of which the large chelate antennæ are most remarkable, being a foot long and only four-jointed,—the terminal joints forming a strong serrated claw. The large mandibles were fully six inches long; the maxillæ, either one or two pairs, with six-jointed palpi; and the great swimming feet consisting of six joints, of which the terminal ones were modified as for swimming, and the basal joints are great foliaceous expansions, which possibly assisted, like the joints of the legs in Limulus, in mastication. From the explanations given by Mr. Huxley in the memoir above referred to, there is a general resemblance both in form and structure to the small Stomapod crustaceans, Mysis and Cuma, two minute forms, which must be arranged very low down in the scale of Decapod crustaceans, and which are also frequently ornamented with a simular sculpture to that of the fossils. There is even a yet greater resemblance in form to the larvæ of the common crab. And if this be accepted, the coincidence in essential structure between such minute and embryonic forms and these gigantic denizens of the old seas becomes most remarkable and interesting, as bearing on the course of development of life throughout geological epochs.

5. *On the Bone Beds of the Upper Ludlow Rock, and the base of the Old Red Sandstone;* by Sir R. I. Murchison, (Proc. Brit. Assoc., August, 1856; Ath. No. 1504.)—Sir Roderic Murchison gave an account of the recent and additional discoveries made in those strata, which, whether they pertain to the uppermost beds of the Silurian rocks, or to the lowest junction strata of the Old Red Sandstone, have been grouped under the term of "Tilestones." In his original description of the uppermost Ludlow rock he had described a certain layer, near their summit, as being characterized by the remains of bones of fishes, principally the defences of Onchus, with jaws and teeth, and numerous coprolitic bodies. But he had also noticed, in several localities, the occurrence of a still higher bed, which seemed to form a passage into the Old Red Sandstone, and in which remains of terrestrial plants occurred. He had further pointed out, that the upper Ludlow rock was the lowest stratum in which the remains of Vertebrata were discovered,—an observation which has remained uncontroverted till the present day, no remains of true fishes having yet been detected in more ancient strata in any part of Europe. In an ascending order, however, it was well known that Ichthyolites augmented rapidly; and the object of the present communication is to show how the recent observations of Mr. Richard Banks, of Kington, and of Mr. Lightbody, of Ludlow, have made us acquainted with the presence of fish remains in two thin courses *above* the original bone-bed of the upper Ludlow rock. The lower of these beds, which, according to the sections exhibited, occurs both at Kington and at Ludlow, was recently inspected by himself, accompanied by Prof. Ramsay and Mr. Aveline, as well as by Mr. Salter. It is a greyish or yellowish flag-like sandstone, the lowest course of which at Kington contains many spines of Onchus, with *Lingula cornea*. This thin layer, and another softer one full of remains of Pterygotus and two species of Pteraspis, are surmounted by the blue or grey-hearted building-stone of Kington, with Pterygotus,

*Lingula cornea*, &c. These again are covered by less massive beds, which contain fragments of plants and large Pterygoti, and which graduate upwards insensibly into more micaceous sandstones, often splitting into tiles. The *Lingula cornea* and *Trochus helicites* together with species of Modiolopsis and a small Beyrichia, all generally considered characteristic of the uppermost Ludlow rock, prevail throughout these strata, with occasional carbonaceous matter and traces of land vegetation; clearly indicating an upward passage towards the younger formation of Old Red Sandstone. The last-mentioned (or middle) fish bed is probably the same as that which Sir R. I. Murchison described in the Silurian System as occurring in Clun Forest and other places. It has recently been laid open by the cutting of the railroad northeast of the town of Ludlow, and exhibits similar relations,—a grey rock beneath passing into an overlying micaceous sandstone. The same succession is obscurely traceable on the right bank of the Ferne, below Ludford. This bed is also characterized by the presence of vegetable remains, seed vessels, jaws and spines of Onchus, with fragments of crustaceans (Pterygotus and Eurypterus), in short, just the same assemblage as that which occurs at Bradnor Hill, near Kington, and has been described by Mr. Banks. Again, on the right bank of the Tane, the next strata in ascending order which are visible, and which have lately been accessible owing to the dry weather, consist of micaceous brownish red sandstone and red marls, with true cornstone concretions, exposed in the bed of the river, which are again followed by other marls and sandstones, surmounted by a band of coarse, greenish, micaceous sandstone, in which are found remains both of fishes and of Pterygotus. The fish remains consist of distinct jaws and teeth of considerable size, of fin defences (Onchus), and the heads of *Cephalaspis Lyellii*, and a new species; together with these, the *Lingula cornea* occurs. The genus Pterygotus having now been found through the upper Silurian rocks, and even so low down as the upper Caradoc formation, can no longer be considered characteristic of the transition beds between the Silurian and Devonian rocks; and as the genera Cephalaspis and Pteraspis are now known to extend their range into true upper Ludlow strata, our views regarding the precise zoological characters, which separate the two formations, must be modified accordingly. As regards the English frontier of the Silurian rocks, the phenomena present no ambiguity; for all the strata, from the *lowest* bone-bed of the true Ludlow rock, which contains so many species of shells of Silurian age, to the *uppermost* fish-bed, which must be included in the Old Red Sandstone, do not exceed forty or fifty feet in thickness,—the upper part of the series constituting a true mineral and zoological passage into the Old Red Sandstone. In conclusion, the author observed, that the lithological term "*tilestones*," if applied either to the top of the upper Ludlow rock or to the base of the Old Red Sandstone exclusively, might mislead; but if applied generally to the beds of transition between the two deposits, it may still be a convenient and applicable term.

6. *On a Fossil Mammal* (*Stereognathus ooliticus*) *from the Stonesfield Slate;* by Prof. Owen, (Proc. Brit. Assoc., Aug., 1856; Ath., No. 1503.)—Prof. Owen exhibited, by favor of the Rev. J. P. B. Dennis, M. A., a portion of a lower jaw, with three molar teeth, of a small mammal,

from the oolitic slate of Stonesfield, Oxfordshire, for which the name of *Stereognathus ooliticus* had been proposed; and after a minute description of the characters of the bone and teeth, he entered upon the question of its probable affinities. These could only be judged of by the peculiarities of certain molar teeth of the lower jaw of the unique fossil. Those teeth presented the singular complexity of six cusps or cones upon the grinding surface, in three longitudinal pairs, the crown of the tooth being quadrate, broadest transversely, but very short *or low*. The jawbone presents a corresponding shallowness and thickness. The cusps are sub-compressed: the outermost and innermost of the three hinder ones are oblique, and converge towards the middle of the crown, being overlapped by the outermost and innermost of the three front cones. The three molar teeth occupy the extent of $4\frac{1}{2}$ lines, or 1 centimeter; each tooth being 3 millimeters in fore and aft extent, and nearly 4 millimeters in transverse extent. After a comparison of these molars with the multicuspic teeth of the rat, the hedgehog, the shrews and Galeopitheci, the author showed that the proportions, numbers and arrangement of the cusps in those Insectivora forbad a reference of the Stereognathus, on dental grounds, to that order. The same negative result followed a comparison of the fossil with the sex-cuspid teeth of the young Manatee. The author finally proceeded to point out closer resemblances to the sex-cuspid teeth of the mammals of the eocene, Hyracothere, Microthere and Hyopotamus; but in these the resemblance was presented only by the teeth of the upper jaw. The lower molar teeth of the Chœropotamus, to which the author deemed those of the Hyracotherium would most closely approximate when discovered, showed a rudiment of the intermediate cones between the normal pairs of cones. The proportional size and regularity of the cones of the grinding teeth of the Stereognathus, give quite a different character of the crown from that of the multicuspid molars of the Insectivora, and cause the sex-cuspid crown of the oolitic mammal to resemble the pente-cuspid and quadri-cuspid molars of the before-cited extinct Artiodactyle genera. Prof. Owen concluded, therefore, that the Stereognathus was most probably a diminutive form of non-ruminant Artiodactyle, of omniverous habits.

7. *On the Dichodon cuspidatus, from the Upper Eocene of the Isle of Wight and Hordwell, Hants;* by Prof. Owen, (Proc. Brit. Assoc., Aug. 1856; Ath., No. 1503.)—Prof. Owen communicated the results of examinations of additional specimens of jaws and teeth of the *Dichodon cuspidatus*, which he had received since his original Memoirs on that extinct animal in the Quarterly Journal of the Geological Society, vol. iv., (June, 1847). The first specimen described supplied the characters of the last true molar tooth of the lower jaw, which had not been previously known. This tooth has six lobes, the additional posterior pair being less than the normal ones, and more simple. The inner surface of the inner lobe has an accessary cusp at the back part of its base, but not at the fore part as in the other lobes. The length of the last lower molar was nine lines, that of the first and second molars being each six lines. A specimen of the *Dichodon cuspidatus* from the Hordwell Sands, in the British Museum, supplied the characters of the permanent incisors, canine, and three anterior premolars of the upper jaw: all these teeth closely corres-

pond in form with the corresponding deciduous teeth, but are of larger size. Finally, a portion of the lower jaw of an aged specimen of Dichodon, in the British Museum, showing the effects of attrition on the last molar tooth, was described, and the results of this additional evidence confirmed the conclusions of the author as to the generic distinction of the Dichodon.

8. *On a Range of Volcanic Islets to the Southeast of Japan;* by Mr. A. G. FINDLAY, (Proc. Brit. Assoc., August, 1856; Ath., No. 1503.)—The recent importance of our commercial relations with Japan, consequent upon the opening of the ports of Nagasaki and Hakodadi to our merchants, and the increasing commerce now developing itself between Eastern Asia and Northwest America, has rendered the great ocean-highway between Nippon and the Bonin Islands of great interest. The dangers of this region to the seaman are much increased by the rapid Japanese current, first shown by the author in 1850 to run from east to west across the North Pacific Ocean, in an analogous course to the Atlantic Gulf Stream. This mighty stream running to the ENE, through the space under consideration, has given rise to the very complicated nature of the so-believed new discoveries. Above thirty of these announcements being, by investigation, reduced to five or six rocky islets of very singular character. The islands nearest to Japan, the Broken Ids, Falsisyo, the Japanese penal colony, and South Island, were shown to be in some cases defectively represented. The Redfield Rocks are those discovered by Broughton, and corrected by Capt. Donnell in 1850, and therefore not a discovery by the United States Japan Expedition in 1854. The islands south of this are, perhaps, Tibbit Island of 1844, then an island or reef of pointed rocks, discovered by Coffin in 1825, afterwards announced as new by Captain Jurien-Lagravière in May, 1850; again announced as new by Captain Rogers in 1851; again in 1852 by Captain Dresher of the Walter, and again in 1856 by Capt. Grove, each person believing that he had discovered a new island. Others similar were also cited. The next group, perhaps, is about eight miles to the south of the last, or lat. 31° 53′ N., long. 139° 59′ E., was discovered in the Dutch corvette, the Koerier, August 24, 1849, and are of a very dangerous character. Jeannette Island, twenty-three miles further south, is doubtful. Smith Island, in lat. 31° 12′, long. 139° 55′, discovered by Capt. Smith of the Heber, March, 1846, is a most singular needle-rock, springing from unfathomable depths to 300 feet high and not more than 250 feet diameter at the base. It has been seen by others. Ponafidin Island of the Russians lies next, to the south. St. Peter's or Black Rock, first seen in 1821, and again in 1853, is a wonderful column of basalt or volcanic glass, 200 feet high, parallel and quite perpendicular sides, not more than 150 feet in diameter, and like a bottle in appearance. It is in lat. 29° 42′, long. 140° 15′. The volcanic nature of these remarkable rocks lying near the meridian of 140° E. indicates a continuation of those immense volcanic ranges which pass along the Kurile Islands, throughout Nippon, the great Japanese island, and thence to the well-known range of spiracles in the Ladrone Islands. At the northern end of this range is the well-known Mount Fusi, 10,000 or 12,000 feet in height, now quiescent. To the south of this volcano is Simoda,—a port between the two capitals of Ja-

pan, Jeddo and Miako, which has been thrown open to the commerce of the United States in 1854. The dreadful earthquake of 1854 at this place was alluded to. It totally changed the character of the harbor of Simoda, destroyed the fine city of Osaca, and injured Jeddo. The wave which was caused by this upheaval of the land traversed the entire breadth of the North Pacific in twelve hours and some few minutes, a distance of between 4,000 and 5,000 miles, demonstrating the depth of that ocean to be between two and three miles. The diagram illustrating the paper showed the singular confusion before mentioned in the hydrography of these small but important positions. The Bonin Islands lie to the southward. They have recently been made the subject of some uncourteous disputation by the Americans as to the right of discovery and ownership. There can be no doubt of their Japanese discovery, and are the Arzbispo Islands of the early Spaniards. Next follows Captain Coffin in 1824–5, who was believed to be an Englishman, but which is controverted by Commodore Perry of the U. S. N. The particulars of the discovery were related. Next, Captain (now Admiral) Beechy saw them in 1827, and took possession of them before the discovery of Coffin was published. They were colonized under the direction of H. B. M.'s consul at Oahu in 1830, the survivors of those settlers still living there. These islands have been lately explored by the United States Japan Expedition, and their volcanic origin established. It was hoped that some authority to repel aggression would be established there, as the islands have now become valuable as a coaling and refitting station for steam-vessels. The Volcano Isles which follow are tolerably well-known, and from these the volcanic submarine ridges diverge to SSE, and SW, several isolated shoals and volcanic rocks having been discovered in these directions. The paper concluded with a hope that our naval officers would endeavor to clear up the embarrassing confusion which had arisen from the imperfect accounts given of this now important region.

9. *On the New Red Sandstone Formation of Pennsylvania ;* by ISAAC LEA, (Proc. Acad. Nat. Sci. Phil., April, 1856.)—Mr. Lea read some notes from a paper he is preparing for the Journal of the Academy on the Red Sandstone Formation of Pennsylvania, and stated that he had, during an excursion last summer, found in the dark shales of that Formation, near Phœnixville, on the Schuylkill, the tooth of a Sauroid Reptile which he thus characterised.

CENTEMODON* SULCATUS. Tooth smooth, rather thick, slightly curved, with trenchant edges, rounded on the exterior portion, sulcate on the lower part near the base, covered with very minute, distinct striæ from the point to the base, which striæ cross the sulcations in slightly oblique lines. Length sixteen-twentieths of an inch; greatest breadth four-twentieths of an inch; pulp cavity large.

On comparing this tooth with *Clepsysaurus Pennsylvanicus*, which he had described from the same Red Sandstone Formation in Lehigh county, it is found to differ very widely. The edge is not serrate on any part as in that genus, nor is it so large or so attenuate. The form, too, is more compressed. It differs in size from the teeth of *Bathygnathus borealis* of Leidy, from the New Red Sandstone of Nova Scotia, being smaller and more attenuate, as well as in having a trenchant smooth edge and not a

* Κέντημα aculeus and ὀδοὺς dens.

serrate edge. It is about the size and approaches the form of Prof. Owen's figure of *Labyrinthodon*, Plate 63 A. f. 2, of his Odontographia, but it is more flattened.

Mr. Lea also stated that in the greenish and blackish shales of the same locality he found two species of *Posidonia*, which genus is so characteristic of this portion of the formation and existing in immense quantities. As they seem to differ from that figured by Sir Charles Lyell, in his Elementary Geology, as coming from the Oolitic coal shale of Richmond, Virginia, Mr. Lea proposed the names of *P. ovata* and *P. parva*, the first being about seven-twentieths of an inch in transverse diameter. The latter is more rotund, and about three-twentieths of an inch in transverse diameter, both being covered with numerous minute concentric costæ over the whole disc.

Near to this locality and superimposed, Mr. Lea obtained a specimen of impure dull red limestone, which contained, on a partially decomposed surface, impressions presenting the appearance of *Foot-marks*, somewhat like *Chelichnus Duncani*, Owen, figured by Sir Wm. Jardine in his Ichnology, for which Mr. Lea proposed the provisional name of *Chelichnus Wymanianus*, after Professor Wyman, of Cambridge, Mass.

From the same formation and locality were procured the impressions of plants, some of which belong to the *Coniferæ*. One of the cones was nearly six inches long and full an inch wide. These were accompanied by other plants of very obscure character, covering large portions of the surface of some of the layers. Mr. Lea also mentioned that he had observed the same Red, Black and Gray Shales at Gwynedd, on the North Pennsylvania Railroad, where he found the same *Posidoniæ*, and some of the same obscure plants, impressions of which covered the surfaces of many of the rocks. A single specimen was obtained of a plant with long leaves somewhat resembling *Noeggerathia cuneifolia*, Brongniart, which is from the Permian.

In the Black Posidonia Shales was found a single Ganoid scale, which is more like *Pygopteris mandibularis*, Agas., from the Marl Slate (Lower Permian) than any other which had come under Mr. Lea's notice. There were other obscure forms observed, which have not yet been satisfactorily found to be analogous to any known forms, but which Mr. Lea hoped to be able to make out when he should figure all the specimens and describe them more at large for the Journal of the Academy.

10. *Descriptions of New Species of Acephala and Gasteropoda, from the Tertiary formations of Nebraska Territory, with some general remarks on the Geology of the country about the sources of the Missouri River;* by F. B. Meek and F. V. Hayden, M. D., (Proc. Acad. Nat. Sci., Philad., viii, 101.)—That portion of the great Tertiary basin from which the fossils described in the following paper were obtained, occupies an extensive area of country near the head waters of the Missouri, chiefly between the 46th and 49th parallels of north latitude, and the 100th, and 108th degree of longitude west from Greenwich. According to the barometrical measurements made by the party charged with the exploration of the proposed northern route of the Pacific railroad, this district varies in its elevation from 1800 to 2700 feet above the present flow of the tidal wave.*

* Some points not crossed by these explorers may be a few hundred feet higher.

In regard to the geographical, topographical, and physical features of this country, its native tribes, its botany, zoology, &c., much interesting information was long since laid before the public by the Reports of Lewis and Clark's and Long's expeditions, by Mr. Catlin, the Prince of New-Wied, Mr. Nuttall and others. More recently, much information of a similar nature has been added by the report of the Pacific Railroad Survey. All these enterprising travellers mention the occurrence of sandstones, clays, lignite, &c., but without giving us much information in regard to the age of these formations, the extent of country occupied by them, or the character of their organic remains.

In 1849, Dr. John Evans traced a great Lignite formation from below Fort Clark, along the Missouri, to a point twenty miles below the mouth of the Yellow-Stone; and in 1850 Mr. Thaddeus A. Culbertson, who visited this country under the patronage of the Smithsonian Institution, saw this formation at two or three points above Fort Union. In a map accompanying a highly interesting memoir on the geology of the Hudson's Bay Territories, published recently by Mr. A. K. Isbister, in the Journal of the Geological Society of London, a large area about the sources of the Missouri, is colored as Tertiary, but so as to convey an incorrect idea of the extent of country occupied by it. About the same time, Mr. Jules Marcou published in the Bulletin of the Geological Society of France, a memoir on the Geology of the United States and the British Provinces, accompanied by a map, on which he colors nearly all the country about the head waters of the Missouri as New Red Sandstone, surmounted along the west shore of that stream by Cretaceous outliers. Between this and the Black Hills he brings up to Cannon-ball River, from the White River basin, a continuous belt of Tertiary. West of this he places a belt of Jurassic, and along the supposed position of the Black Hills he runs a stripe of eruptive and metamorphic rocks, flanked on the east and west by Carboniferous formations. On the west side of the Black Hills he colors another extensive district of Jurassic. In all this Mr. Marcou is certainly mistaken, excepting in regard to the eruptive and metamorphic rocks of the Black Hills; there may also be Carboniferous formations there, but they have not yet been recognized as far north by two or three hundred miles, as laid down by him.

Leaving for a future occasion all local and other details, we now propose to give a brief general sketch of the extent and boundaries, as far as we can, of that portion of the great Tertiary lignite formation from which our fossils were collected, with a few remarks upon its probable age, and relations to the White River basin, as well as to the Cretaceous formations upon which it reposes.

Ascending the Missouri from Fort Pierre, we find on reaching a point five miles below Heart River, about the 47th parallel north, that the Cretaceous formations which are so conspicuous for many hundred miles along the river below, pass by a gentle north or north-west dip beneath the water level, to be succeeded on both sides of the river by tertiary. Although this is the first point where the tertiary beds come down to the water level, they are known to occupy the higher country back from the river, on the west side, as far south as the vicinity of *Sawacanna* or Moreau river, and still farther west they go as far south as some of the north-

west branches of the Cheyenne. Cannon-ball river, Watahoo, and other small tributaries, however, cut down to the Cretaceous beds some little distance back from the Missouri. On the east side of the Missouri the Tertiary is bounded on the south, nearly opposite the mouth of Cannon-ball river, by a range of Upper Cretaceous hills bearing off to the northeast. South of the Moreau, a similar range, known as Fox Hills, extends from near the Missouri to about 102° of west longitude, where it is interrupted by a small tributary of the Cheyenne. West of this small stream, the same range of Upper Cretaceous hills, known perhaps by other local names, bears round to the northwest, crossing the head branches of the Little Missouri so as to strike the Yellow-Stone river about ten miles below the mouth of Powder river; forming nearly all this distance the south and southwest boundaries of that portion of the great Tertiary basin lying in the immense bend formed by the Missouri and Yellow-Stone rivers. To comprehend how this range of hills could traverse the country in this way, it must be borne in mind that the Black Hills are laid down on most of the published maps of this country as extending a long distance too far north.

Returning to the point near Heart river, from which we first set out, we find on ascending the Missouri, that the Cretaceous strata again rise to view at a few points not far below Fort Clark, but even here the country on each side is composed of Tertiary. It was at one of these localities the Prince of New Wied collected a nearly entire skeleton of *Mosasaurus Maximiliani* (Goldf.). From the vicinity of Fort Clark we know of no other place where the Cretaceous beds make their appearance until about twelve miles below the mouth of Milk river, (lat. 47° N., long. 104° W.,) the country on both sides of the Missouri all this great distance being made up of Tertiary formations, the northern and eastern limits of which are unknown to us. Immediately along the margins of Milk river, Cretaceous beds are seen on both sides as far up as we have any knowledge of the country, though the higher country back from the river is Tertiary. From the point below the mouth of this stream on the Missouri, where the Cretaceous beds first make their appearance, they are seen to rise higher and higher as we ascend the Missouri, in consequence of their inclination to the east or northeast. On the north side of the Missouri, between it and Milk river, the higher portions of the country back from the Missouri, are also composed of Tertiary beds.

The same formations likewise occupy nearly all the country between the Missouri and the Yellow-Stone, as far west as the vicinity of Muscleshell river, where they thin out on the summits of Cretaceous hills. The hills, however, near the Missouri, between Milk and Muscleshell rivers, are also mainly Cretaceous, the Tertiary being for the most part worn away by atmospheric agencies.

On both sides of the Yellow-Stone, only Tertiary strata are seen from near the mouth of Powder river as far up as the mouth of the Big Horn. How far beyond this they extend we do not know, though we have received Tertiary fossils from intelligent traders, collected as far up the Big Horn as one of its tributaries known as Little Horn river. From another point as far west on the Yellow-Stone as Rose river, we received a few Cretaceous fossils. As to the limits of the Tertiary up Powder and

Tongue rivers, we have no definite information. The traders say the same kind of lignite beds seen along the Yellow-Stone, occur along the banks of the former as much as one hundred and fifty miles above its mouth.

The foregoing hasty sketch is given more with a view of showing the extent of the country occupied by this great Tertiary lignite formation, than with any hope of conveying a definite idea of its precise limits. If it should prove to be only a part of the same extensive fresh water lignite formation observed by Sir John Richardson on the Saskatchawan, of which we have little doubt, then it is highly probable the lignite and coal formations mentioned by Mr. Isbister as flanking the eastern slope of the Rocky Mountains, in the form of a continuous belt from the Saskatchawan to the Arctic Ocean, belong to the same epoch.

For the most part, these deposits in Nebraska consist of beds of gray, yellowish, whitish, and blue sand, sandstone, clay, &c., with alternating strata and clay. These beds of lignite often take fire spontaneously, from heat generated in the decomposition of iron pyrites, and burn for many years at a time, sending forth suffocating sulphurous vapors, and causing such an intense degree of heat as to fuse the contiguous clay and sand into masses presenting every degree of compactness, from that of obsidian to light vesicular lava. In some of the argillaceous beds, great numbers of beautiful fossil plants are found, a fine series of which was collected and placed for investigation in the hands of Dr. J. S. Newberry, the well known botanical palæontologist of Cleveland, Ohio. The remains of Mollusca collected from these formations, over a wide extent of country, present a remarkable uniformity of character, and as may be seen by the following paper, are all, excepting a few land shells, referable to genera usually found in fresh and brackish waters. It is an interesting fact that the most nearly allied living representatives of many of these species are now found inhabiting the streams of South Africa, Asia, China, and Siam, apparently indicating the existence of a tropical climate in these latitudes at as late a period as the Tertiary epoch.*

Although there can be no doubt that these deposits hold a rather low position in the Tertiary System, we have as yet been able to arrive at no very definite conclusions as to their exact synchronism with any particular minor subdivision of Tertiary, not having been able to identify any of the Mollusca found in them with those of any well marked geological horizon in other counties. Their general resemblance to the fossils of the Woolwich and Reading series of English geologists, as well as to those of the great Lignite formations of the southeast of France, would seem to point to the lower Eocene as their position. Yet it may be possible these resemblances have resulted from the action of precisely similar causes at a somewhat later period.

It is a little remarkable that these formations differ in many respects from those of the White River basin lying so near on the south. In the first place they generally contain more sand, are usually characterized by beds of lignite, and as yet have furnished no remains of Mammalia;

* We are under many obligations to Dr. Issac Lea, of Philadelphia, for the privilege of comparing our fossil species with analogous forms in his magnificent collection of recent shells.

while the White River basin is more argillaceous, appears to be destitute of lignite, and is well known to be one of the most remarkable repositories of extinct mammalian remains on the face of the globe. In addition to this, not one of the species of Mollusca in our collection from the Lignite formations, is identical with any of those described by Dr. Evans and Dr. Shumard from the White River basin.

*Formations immediately beneath the Tertiary in this district.*—It would seem that the change of physical conditions which closed the Cretaceous epoch and ushered in the Tertiary, in this part of the world at least, was gradual, not violent. We find that even while the Cretaceous conditions still existed, (during the deposition of No. 5 of the series*) the approaching close of that state of things, and the coming of the Tertiary era, were foreshadowed by the introduction of *Fasciolaria*, *Pleurotoma*, and *Belemnitella*, with many shells of other genera, quite as near in their specific affinities to Tertiary as to Cretaceous forms; while the sea was gradually becoming more shallow, as is shown by the increase of *Gasteropoda*. We even know from the presence of a few remains of *Lycopodiaceous* plants, and an occasional unbroken leaf of some *Exogenous* tree, that there was dry land at this time somewhere not very far away. Gradually, as we ascend in the series, the strictly marine animals disappear, and we meet with *Ostrea*, *Corbula*, and *Cerithium*, mingled in the same bed with *Melania*, *Paludina*, *Physa*, *Cyrena*, &c., all of tertiary types; while a little higher in the series we find at some places only the remains of land and fresh-water Mollusca.

From the above facts, especially the presence of *Pleurotoma*, *Fasciolaria*, and *Belemnitella*, in this upper member of the Cretaceous system of this country, we cannot think it represents any part of the Green Sand of English geologists. Numerous well marked Cretaceous forms show it cannot be Tertiary, consequently we think it must represent some portion of the true chalk. We are by no means inclined, however, to adopt the views of M. Alcide D'Orbigny, who regards all the Cretaceous formations of the United States and Western Territories as referable to a later epoch than the Green Sand, as the next succeeding formation below that of which we have just been speaking, (No. 4 of the series), is characterized by numerous fossils of unquestionable Green Sand type. We think confusion has been created in tracing out the parallelism between American and European Cretaceous formations, by fossils from different positions in this country having been mingled together and described as if they occurred in the same bed.

*Formations at the base of the Cretaceous Series of this district.*—As previously stated, near the mouth of Milk river, Cretaceous strata which are not seen for a long distance below this on the Missouri, again rise to view. They consist of the upper two members of the series (No. 5 and No. 4) which, in consequence of their inclination to the east, are found to rise higher and higher as we ascend the river, so that nearly all the hills close to the Missouri, between Milk and Muscleshell rivers, consist of these formations. Some four or five miles below the mouth of Muscleshell

* For a section of the rocks of this country, see a paper by James Hall and F. B. Meek in the Memoirs Am. Acad. Arts and Sci., vol. 5, New Series. Likewise a paper by F. B. Meek and F. V. Hayden in Proceed. Acad. Nat. Sci. Philad., March, 1856.

river, a lower rock, a sandstone, rises above the water level. This is probably No. 1 of the series, No. 2 and No. 3 not being represented here. It is worthy of note that out of two species of *Mactra*, two of *Tellina*, two of *Inoceramus*, one of *Pholadomya*, two of *Natica*, and one *Baculite*, found in this rock, not one is known to occur in any of the higher formations, and some of these species are not unlike *Neocomian* forms.

In consequence of the increasing inclination of the strata, this last mentioned sandstone rises in the vicinity of North Mountain river as much as 250 feet above the Missouri. Here, or near this, begins a wild and desolate region, known as the *Mauvaises Terres* or Bad Lands of the Judith. At various places in these Bad Lands a sandstone similar to No. 1 was seen alternating with beds of clay and lignite, all of which are upheaved and much distorted. It was found impossible to devote to the examination of these formations time enough to determine their relations to the Cretaceous and Tertiary strata of this region, without running the risk of being cut off from the party and murdered by the Indians. Amongst a few fossils that were collected here, however, Prof. Leidy finds teeth which he refers to two or three genera of large *Saurians* allied to the *Iguanodon*, *Megalosaurus*, &c. There are also in the collection from some of these beds, one or two species of *Unio*, one or more of *Cyclas* or *Cyrena*, and a few crushed specimens of *Gasteropoda* like *Paludina* and *Melania*. From these facts, we are strongly inclined to think with Prof. Leidy, that there may be here, at the base of the Cretaceous system, a fresh-water formation like the Wealden. Inasmuch, however, as there certainly are some outliers of fresh-water Tertiary in these Bad Lands, we would suggest that it is barely possible these remains may belong to that epoch, though the shells appear to be all distinct species from those found in the Tertiary at all the other localities in this region.

We remember seeing in 1853, between the mouth of Big Sioux and Platte rivers on the Missouri, some exposures very similar to those of the Bad Lands of the Judith, excepting that there appeared to be no beds of Lignite. We saw no fossils in these beds, but were at that time impressed with the opinion that they belonged to the lower part of No. 1, which is well exposed a little higher up the river at the mouth of the Big Sioux, but soon dips beneath the water level to be seen no more between there and the far distant point already mentioned, near the mouth of Muscle-shell river.*

[Here follow descriptions of species: *From Fort Union*, Paludina Leai; —*From three miles above Fort Union*, Cyclas formosa, C. fragilis, C. subellipticus, Pupa helicoides, Physa longiuscula, P. rhomboidea.—*Three miles below Fort Union*, Bulimus? teres, B.? vermiculus, Limnæa tenuicosta, Physa Nebrascensis, Planorbis umbilicatus, Velletia (Ancylus) minuta, Paludina retusa, Valvata parvula, Melania minutula.—*Ten miles below Fort Union*, Paludina trochiformis, P. Leidyi.—*Ten miles above Fort Union*, Melania multistriata, M. Nebrascensis.—*Near Moreau river*, with bones of Titanotherium? Cyrena Moreauensis, C. intermedia.—*Bad Lands of the Judith*, Cyrena occidentalis, Physa subelongata, Paludina vetula, P. Conradi, Melania convexa.—*Mouth of the Judith*, associated

* The foregoing remarks are based upon the observations and collections of Dr. Hayden.

with *Ostræa subtrigonalis* Evans and Shumard, also *Melania*, *Paludina*, and other fresh-water shells, Corbula subtrigonalis, C. perundata.—*Fort Clark*, Corbula mactriformis (associated with *Melania*, *Paludina*, etc.,) Bulimus Limneiformis, B. Nebrascensis, Paludina multilineata, P. peculiaris.—*Little Horn River*, Planorbis convolutus.—*Yellow-Stone River, 30 miles above the mouth*, Melania Anthonyi.—*Near headwaters of Little Missouri*, Cerithium Nebrascencis.]

## III. BOTANY AND ZOOLOGY.

1. *Alph. DeCandolle: Géographie Botanique raisonnée, ou Exposition des Faites principaux et des Lois concernant la Distribution Géographique des Plantes de l'Epoque Actuelle.* Paris and Geneva, 2 vols., 8vo, 1855.—Pressing engagements have prevented the fulfilment of our promise to make a detailed examination of this work. We exceedingly regret this; for the *Géographie Botanique* of DeCandolle is not only one of the most important works of our day, but one which addresses and will greatly interest, a much broader circle of scientific readers than any other modern production of a botanical author. It is, and probably long will be, the standard treatise upon a wide class of questions, highly and almost equally interesting to the botanist, the zoologist, the geologist, the ethnologist, and the student of general terrestrial physics. To its production the author has devoted no small portion of the best years of his life; and it bears throughout the marks of untiring labor, directed by a remarkably sound, conscientious, and thoroughly systematic mind. Along with the admirable methodical spirit which is his by rightful inheritance, the younger DeCandolle brings to these investigations a particular aptitude for numerical and exact forms, an intimate acquaintance with general physical science, and considerable ethnological and philological learning; which last is turned to good account in his chapters on the history of cultivated and naturalized plants. The result in the work before us,—even if there were no other claims to the distinction,—may fairly be said to go far towards inscribing the name of DeCandolle anew in that select list of philosophical naturalists in which his father holds so eminent a position.

To give some idea of the topics considered in these volumes, and of the order of investigation (which proceeds in an admirable course, from the more simple, general, and better known facts and principles towards the more complex, hypothetical and obscure), we will copy the titles of the chapters, twenty-seven in number; which are arranged in four books, and subdivided into articles, and these again into sections, to such an extent as to fill eight closely printed pages with the bare enumeration. Indeed, this repeated subdivision gives a rigid and rather tedious aspect to some parts of the work, and involves occasional repetitions; but it would not be easy to collocate well and clearly so vast an amount of materials in any better way.

The first Book is occupied with some preliminary considerations upon the way in which temperature, light, and moisture act upon plants. Its three chapters treat of the relations of plants to surrounding physical conditions, and especially to heat and light; and contain the author's

happy distinction between the temperatures actually operative in vegetation, and those which (being below the freezing point, &c.) are altogether null for vegetation, and ought to be eliminated from the tables of mean temperature, when these are viewed in relation to the Northern and Southern geographical range of species.

In Book 2, Geographical Botany, or the study of species, genera, and families, from a geographical point of view; Chap. 4 relates to the limitation of species upon plains and upon mountains, and the probable causes of their actual limits, applied both to spontaneous and cultivated plants; and there is a good endeavor to show that the Northern limit of species is fixed rather by the sum of heat available for vegetation during the growing season, than by the mean temperature of the year. Chap. 5 treats of the shape of the area occupied by a species, a very curious point; and it seems that the area of species inclines to be circular or elliptical. Chap. 6 treats of the association or disjunction of the individuals of a species in its area. Chap. 7 treats of the area of species as to extent of surface, considered as to the families they belong to, as to stations, as to size and duration of the plant, and as to the character of the fruit and seed, whether affording facilities to dispersion or not. Chap. 8 considers the changes which may have taken place in the habitation of species, and discusses with great fullness the whole subject of naturalization, the obstacles in the way, the causes and means of transport, and the interchanges which have been effected between the New and the Old Worlds. Chap. 9 is a very long and interesting one, on the geographical origin of the principal cultivated plants, not only those intentionally, but also those *unintentionally cultivated* by man,—a chapter full of valuable matter, carefully collected and well discussed.* Chap. 10 treats of disjoined species,—those occupying two or more widely separated areas, and not in intermediate stations. Chap. 11 discourses of the early condition and probable origin of the existing species; and brings out the various facts which go far to prove the *geological antiquity of the greater part of existing species;* and that their creation was probably successive. Chap. 12 treats of genera, and their geographical distribution, and maintains the view, (in which we by no means coincide) that genera are truly naturally-limited groups, even more so than species. Chap. 13 is devoted to the distribution of the species of a genus within its area. Chap. 14 treats of the extent of surface occupied by genera. Chap. 15 discourses of the origin and duration of genera. Chap. 16–19 treat of families, as to their area, geographical limits, the distribution of species within the area of the family, &c.

The Third Book is devoted to Geographical Botany, or the characters of different countries considered as to their vegetation. Chap. 20. of the characters of the vegetation of a country; considered, in Chap. 21, as to the relative numbers in the great classes respectively. Chap. 22, com-

* It is singular that M. De Candolle should be so slow to abandon the idea that the aborigines of Carolina, or any other part of North America cultivated or knew anything of the Potato, which, if Raleigh obtained them in Carolina, were certainly imported thither. But, though our aborigines had no *potatoes*, they had *pumpkins* or *squashes* and *beans*, which all writers upon the history of cultivated plants have overlooked, except the late Dr. Harris.

parison of different countries in respect to those natural orders which abound most in species; and Chap. 23, as regards their most characteristic natural families. Chap. 24, on the variety of vegetable forms in different countries and in the world at large, *i. e.*, the probable number of species; the proportion of genera to species, and of orders to genera and species. Chap. 25, the division of the earth's surface into natural botanical regions. Chap. 26, sketch of the vegetation of different countries in respect to the probable origin of their existing species, &c.

The Fourth Book, of a single brief chapter, consists merely of a summary of the author's general conclusions. We give these entire, for convenience availing ourselves of a translation in Hooker's Journal of Botany.*

"The plants now inhabiting the globe have survived many changes, geological, geographical, and, latterly, historical. The history of their distribution is hence intimately connected with that of the whole vegetable kingdom.

To explain existing facts, it is fortunately unnecessary to adopt any conclusion upon the most obscure hypotheses of Cosmogony and Palæontology, or on the mode of creation of species, the number originally created, and their primitive distribution. Botanical Geography can indicate certain probabilities, certain theories, but the principal facts in distribution depend upon more recent and less obscure causes. It suffices to understand and to allow certain facts and theories, which appear probable, namely, that groups of organized beings under different hereditary forms (Classes, Orders, Genera, Species, and Races), have appeared at different places and at different times; the more simple perhaps first, the more complicated afterwards; that each of these groups has had a primitive centre of creation of greater or less extent; that they have, during the period of their existence, been able to become more rare or common, to spread more or less widely, according to the nature of the plants composing them, the means of propagation and diffusion they are possessed of, the absence or presence of animals noxious to them, the form and extent of the area they inhabit, the nature of the successive climates of each country, and the means of transport that the relative positions of land and sea may afford; that many of these groups had become extinct, whilst others have increased, at least as far as can be judged from comparing existing epochs with preceding ones; and lastly, that the latest geological epoch the Quaternary, (that which preceded the existence of man in Europe, and which followed the latest elevation of the Alps), has lasted many thousand years, during which important geographical and physical changes have affected Europe and some neighboring countries, whilst other regions of the globe have suffered no change, or have been exposed to a different series of changes.

"Thus the principal facts of Geology and Palæontology, reduced to the most general and incontestible, suffice to explain the facts of Botanical Geography, or at least to indicate the nature of the explanation, which it requires the progress of many sciences to complete.

* We take this occasion to commend to our readers the detailed notice of De Candolle's work, given last spring, and summer, in a series of the numbers of Hooker's Journal. It comprises a careful abstract of these volumes, and a critical commentary upon many points, abounding in acute and original remarks.

"The most numerous, the most important, and often the most anomalous facts in the existing distribution of plants, are explained by the operation of causes anterior to those now in operation, or by the joint operation of these and of still more ancient causes, sometimes of such as are primitive (connected with the earliest condition of the planet). The geographical and physical operations of our own epoch play but a secondary part. I have shown that in starting from an original fact, which it is impossible to understand, of the creation of a certain form, in a certain country, and at a certain time, we ought to be able, and sometimes are able, to explain the following facts, chiefly by causes that operated previous to our own epoch:—1, the very unequal areas occupied by Natural Orders, Genera, and Species; 2, the disconnection of the areas that some of the species inhabit; 3, the distribution of the species of a genus or family in the area occupied by the genus or family; 4, the differences between the vegetations of countries that have analogous climates and that are not far apart, and the resemblance between the vegetation of countries that are apart, but between which an interchange of plants is now impossible.

"The only phenomena explicable by existing circumstances, are—1, the limitation of species, and consequently of genera and families, in every country where they now appear; 2, the distribution of the individuals of a species in the country it inhabits; 3, the geographical origin and extension of cultivated species; 4, the naturalization of species and the opposite phenomenon of their increasing rarity; 5, the disappearance of species contemporaneous with man.

"In all this we observe proofs of the greater influence of primitive causes, and of those anterior to our epoch; but the growing activity of man is daily effacing these, and it is no small advantage of our progressing civilization that it enables us to collect a multitude of facts of which our successors will have no visible and tangible proof."

An Appendix, indicating the researches now needed for the advancement of Geographical-Botanical science, under several heads, addressed respectively to physicists and meteorologists, to geographers, to geologists, to vegetable physiologists, descriptive and travelling botanists, and to philologists, brings these most interesting volumes to a conclusion.

Our present object is to call the attention of American naturalists and natural philosophers to this work, not to criticise it. That would require much consideration and a wider range of knowledge than we can pretend to. There are, however, several topics upon which we are inclined to venture a few remarks, as fitting opportunities occur. A. G.

2. *Origin of the Embryo in Plants.—Die Befruchtung der Phanerogamien*, Leipsic, 4to, 1856, is the title of a new and important memoir by a young investigator, Dr. Radlkofer, of Munich; whose name bids fair to be celebrated for having terminated by his investigations the great controversy of our day in vegetable reproduction, namely, the respective functions of the pollen and the ovulum. Our notice in the July number of the Journal, recorded the recent history of investigations in this department, as far as then known to us. We now learn that the Schleidenian view, viz: that the embryo is formed of (or in) the extremity of the pollen-tube,—has at length been definitely abandoned, both by its author, and

by Schacht, of late its most strenuous and able defender. The conversion in this case has been accomplished by one of Schleiden's own pupils, viz: by Dr. Radlkofer, who was authorized to announce this result in his memoir; and more recently Schacht, having essentially confirmed Radlkofer's views by his own observations, now admits that the pollen-tube exerts merely a fertilizing influence upon a previously existing *corpuscle* in the embryo-sac, which thereupon forms an investing coat of cellulose, and becomes the germ of the embryo. This particular view, Prof. Henfrey (in Ann. and Mag. Nat. Hist. for Sept., 1856,) claims as original with himself, and advanced in a paper read before the Linnæan Society last March; also briefly in the article "Ovule," in the Micrographic Dictionary, published a year ago, asserting "that the germinal vesicles (or corpuscles) exist in the embryo-sac before fecundation, not as complete cells, but as corpuscles of protoplasm which acquire their cellulose coat after the fertilization by the agency of the pollen-tube." But as the exactly analogous fact had been already demonstrated in the case of the spores of Algæ, &c.) "the assertion of the opinion" in the present case was very natural; though the researches referred to may be very important.

If we rightly understand the statement, Dr. Radlkofer maintains that it is not the corpuscle or vesicle contiguous to the pollen-tube, but a second one, next to the former, which becomes fertilized, and develops the embryo, and which accordingly is never in contact with the pollen-tube;—a view which may readily be harmonized with Tulasne's beautiful researches. A. G.

3. *Bentham, Notes on Loganiaceæ, (in Journal of the Proceedings of the Linnæan Society,* No. 2.)—A most judicious and thorough revision of this group of *Rubiaceæ* with a free ovary, or "a sort of artificial offset from that family," which it becomes necessary in practice to separate. We cite a portion of the introductory remarks, for the special benefit of those who maintain that families, genera, &c., are as really and strictly limited in nature as they are in our systems, i. e., when our systems are as perfect as they practically can be.

"Our natural orders, with all the improvements they have received from the most philosophical of modern botanists, are yet as dissimilar in definiteness of circumscription and apparent conformity to nature, as they are in extent. Some indeed, including the two most numerous of all, are so well characterized as to admit of no doubt. The *Cruciferæ*, *Leguminosæ*, *Umbelliferæ*, *Compositæ*, *Labiatæ*, *Palmæ*, *Orchideæ*, *Cyperaceæ*, *Gramineæ*, and several others, comprehending two-thirds of the known species of plants, are admitted by all botanists without any variation, and although, amidst the thousands of species comprised in each, there may be some one or two which may offer an exceptional character or anomalous structure, indicating some slight approach to other groups, yet we cannot have the least hesitation as to where to draw the line of demarcation. The Himalayan *Megacarpæas*, although polyandrous, are still decidedly Cruciferous, not Capparideous. The distinction between *Leguminosæ* and *Rosaceæ*, although so difficult to be expressed in words, is yet so clearly defined, that we find no single genus or species ever considered as intermediate, and, although the passage from the former into *Terebinthaceæ* through *Copaifera* and *Connarus* be really more gradual,

yet it is still between those two genera that the limits are placed by universal consent; so are they as irrevocably fixed between the closely allied genera *Teucrium* and *Vitex*, which form the connecting link between *Labiatæ* and *Verbenaceæ*. The vast orders of *Umbelliferæ* and *Compositæ* are equally isolated, notwithstanding the anomalous inflorescences of *Horsfieldia* and some others in the former, and of *Xanthium* in the latter, which at first sight disguise their characters. The few species of *Apostasieæ* are but anomalous *Orchideæ*, rather explaining their structure than connecting them with any particular order. *Cyperaceæ* and *Gramineæ* retain their typical structure through all the singular modifications hitherto observed.

"There are other orders again, even amongst the most numerous in species after the *Compositæ* and *Leguminosæ*, which are admitted on all sides to be natural, but upon whose precise limits few botanists can be made to agree, an almost continuous chain of intermediate groups connecting them with adjoining ones. Here the severance has generally been made wherever the links have appeared the weakest; but as these weak points have been variously appreciated by different minds, and no definite standard has been adopted for testing them, the greatest uncertainty has been the consequence. *Malvaceæ* are connected with *Tiliaceæ* by numerous genera, which some would unite into one intermediate order, whilst others consider them as constituting from two to six or seven independent ones, and others again propose uniting more or less of these groups with *Malvaceæ*. The *Memecyleæ* are in the eyes of some botanists one or two intermediate families between *Melastomaceæ* and *Myrtaceæ*, whilst for others they are but a tribe of the former. So it is with the connecting groups between *Myrtaceæ* and *Passifloreæ*, between the latter and *Cucurbitaceæ*, &c. Amongst some of the largest and most universally recognized Monopetalous orders the connexion is still more gradual, and the limits proposed more arbitrary. There can be no doubt that *Rubiaceæ*, *Apocyneæ*, *Gentianeæ*, and *Scrophularineæ* are large independent orders, indicated in nature, yet those genera now amalgamated under the name of *Loganiaceæ* bind them so firmly together, that some of them will be found even more closely allied to certain others of each of the above orders respectively than they are to each other. On the other side, *Scrophularineæ* themselves pass imperceptibly into *Solaneæ*, *Bignoniaceæ* or *Convolvulaceæ*, and through these into several others.

Since the metaphor of a chain or linear series has been found inadequate for the illustration of the connexion of the natural groups, that of a geographical area or map has been more generally resorted to. In following out this idea, we may compare the natural system to an extensive country more or less densely wooded. Here the *Compositæ*, *Leguminosæ*, and other well-defined orders may be represented by dense forests clearly separated from all others by open spaces all around them, although here and there a solitary tree or a small cluster may stand a little out from the general boundary-line. The *Malvaceæ* and *Tiliaceæ*, the *Melastomaceæ* and *Myrtaceæ*, the *Myrtaceæ* and *Passifloreæ*, these again and the *Cucurbitaceæ*, would not be separated by any clear open space, but by a tract still wooded, but of less density, in which here and there the trees would be so thinly scattered as almost to break the connexion. So

the above-mentioned Monopetalous orders, the *Rubiaceæ*, *Apocyneæ*, *Gentianeæ*, and *Scrophularineæ* would be typified by large and dense woods rather widely separated from each other, but the intervening space would be dotted over with solitary trees or small clusters representing our *Loganiaceæ*. Many of these may be very near to the surrounding woods, and considerable clear spaces may intervene between some of them; yet, in mapping out the country, it may be more convenient to draw the line close round the frontiers of the whole space, than to portion it out into projecting parcels annexed to the adjoining woods.

On a careful examination, it will be found that almost the whole of the *Loganiaceæ* lie very near to some part or other of the vast field of *Rubiaceæ*, although by their free ovary they are absolutely and (with very few exceptions) clearly separated. The connecting genera with *Apocyneæ*, *Gentianeæ*, and *Scrophularineæ* are on the other hand much fewer, but the union is much closer. With *Scrophularineæ* in particular, although the general affinity is more remote, the few intermediate genera and species are intermediate in every respect, in habit as in technical character. The main distinction, the presence of stipules in *Loganiaceæ*, disappears very gradually, and the difficulty of drawing the line is the greater from there being no general habit or family resemblance to unite the several members of the *Loganiaceæ*. A somewhat arbitrary decision is therefore here unavoidable, and we can only direct our best endeavors to the adoption of that demarcation which shall interfere the least with the circumscription of the allied orders."

One of the most interesting facts of detail in the memoir is the identification of a second species of our genus *Gelsemium* (the so-called *Jessamine* of our Southern States) in China (Hong Kong) and Sumatra; and another is the suppression of the genus *Ignatia*, it being proved to have been founded on the blossoms of the Rubiaceous genus *Posoqueria*, and the seed of a *Strychnos*. A. G.

4. *The Flowers of the Pea-Nut* (*Arachis Hypogæa*, L.)—Mr. Bentham authorises us to state that the views formerly published by him attributing to *Arachis* two very distinct kinds of flowers,—namely, one achlamydeous and fertile, the other complete but sterile,—he is now satisfied are incorrect. The mistake here acknowldged was first pointed out by Hugh M. Neisler, Esq., last year, in this Journal (vol. 19, 2nd ser., p. 212, March, 1855). Mr. Neisler, who has enjoyed the best opportunities of studying the living and fruitful plant in Georgia, where it is cultivated in gardens, came to the conclusion that "the flowers of *Arachis hypogæa* are all petal-bearing and all fertile." This communication called out an "additional note" by Mr. Bentham, (in the Kew Journal of Botany, and reprinted in this Journal, vol. xx, p. 202, Sept. 1855), reiterating his former views, and announcing that he had confirmed them by new observations upon *Arachis* and its allies. Mr. Bentham now informs us that he has been made aware of his mistake, recently, through the examination of a large number of spikes of *Stylosanthes* from their earliest stage of development. He remarks that "although I always found fecundated ovaries very different in the shape of their short styles from the base of the style in the unopened or just-expanded flowers; yet after some time I succeeded in tracing, as Mr. Neisler has done in

*Arachis*, the change from the one to the other. The moment the style breaks off, the lower fragment curves back, and forms at the end of it what I always took for a thickened stigmatic surface; but it is a mere callosity which, when examined under the microscope, shows no stigmatic papillæ. Loth as I am to be convinced of so gross an error, I must beg of you to do *amende honorable* for me to Mr. Neisler in any way you may think proper."—We are still inclined to think, but without a fresh examination, that the more fruitful flowers of *Stylosanthes* and *Lespedeza*, although similar to the others in structure, are commonly precociously fertilized in the bud, as they are in *Impatiens* and many other plants, in which, however, the fully-developed blossoms also become fruitful under favorable conditions. A. G.

5. *Martius, Flora Brasiliensis*; fasc. 16 and 17, 1856.—This imperial Flora is now carried on with such spirit that this new and large part (of two fasciculi combined) follows hard upon the last. The present part is mostly the work of Prof. Miquel, of Amsterdam. It comprises first the *Primulaceæ*. These are insignificant both in number and interest in the Brazilian flora, consisting merely of *Pelletiera* (which Miquel suspects may be a *lusus* of Asterolinon), four species of *Anagallis* (most of them introduced, no doubt), two of *Centunculus* (one of which, like our N. American plant, is identified with the European C. minimus), and six species of *Samolus*, among them both S. Valerandi, of Europe, and S. floribundus. 2. The *Myrsineæ;* to which we are pleased to see Miquel reunites both the *Theophrasteæ* and the *Ægicereæ*, and suggests that all might as well be referred as suborders to the *Primulaceæ*. It is more convenient to retain the two groups as orders, but it should be kept in mind that they are based on convenience and general habit, and not upon any important ordinal characters. The *Myrsineæ* of Brazil here embrace 56 species, about one-fifth or one-fourth of the known species of the group. 3. The *Ebenaceæ;* consisting of 4 species of *Diospyros*, and 3 of *Macreightia*. 4. The *Symplocaceæ*, admitted as an order of a single genus; but no character is mentioned in the diagnosis which definitely distinguishes it from the Styracaceæ, and some Brazilian species are noticed with even as few as five stamens.—Von Martius himself has illustrated three remarkable *genera incertæ sedis*, namely, *Diclidanthera* and *Moutabea*, which he develops the affinities of with great acuteness, and regards as a monopetalous, regular, and generally 5-carpellary form of *Polygalaceæ;* and *Hornschuchia*, which, with all its anomalies, he refers to the *Lardizabalæ*. The present part is illustrated by 50 plates, besides two *Tabulæ Physiognomicæ*. A. G.

6. *L. R. Tulasne: Monographia Monimiacearum*. Paris, 1855, pp. 163, tab. 10.—An admirable memoir, contributed to the *Archives de Museum d' Histoire Naturelle*, vol. 8, illustrating a small family of plants, long of obscure affinity. These had for the most part been approximated to the *Laurineæ* and *Urticaceæ:* with the latter they have nothing in common; with the former only a similarity in sensible properties, and occasionally in the structure of the anther. It is now clear that the relationship of the family is with polypetalous apocarpous orders; and that it is to be associated either with *Calycanthaceæ*, or with the group of orders of which *Magnoliaceæ* may be assumed as the leading type.

Tulasne contends for the alliance with the former, relying on the general symmetry of the flowers, the perigynous insertion, and the opposite leaves. Dr. Hooker, following Lindley, apparently with more reason, adopts the other view;—assigning higher importance to the albuminous seeds and small embryo, and relying on "the principle long ago laid down by Mr. Brown, that the most perfect species of a group ought to be kept in view in determining the affinities of the whole; and therefore, laying great stress upon the genus *Hortonia*, which is hermaphrodite and petaliferous, and which, when founded, was very naturally referred to the *Schizandreæ* by Dr. Wight. The plates of this memoir, mostly designed by the author's accomplished brother, are truly admirable. A. G.

7. *Chloris Andina: Essai d'une Flore de la Region Alpine des Cordillères de l'Amerique du Sud;* par H. A. WEDDELL, M.D., etc. Paris: livr. 1–4, 4to, tab. 1–26.—This belongs to the botanical part of the publications of the Expedition of Count Castelnau,—an expedition made from Rio de Janeiro to Lima and then from Lima to Para. Dr. Weddell, who accompanied the expedition, restricts his labors, in the first instance, to the flora of the Andes within the alpine region. Following the order sketched by his late preceptor, the lamented Adrien de Jussieu, he begins with the *Compositæ*. These four fascicles are devoted to that vast family, and one or two more will evidently be required for its completion. The manner in which a botanist handles such a family as the *Compositæ*, affords a fair test of his calibre; and thus far Dr. Weddell comes fully up to the high expectations which have been formed of him. We admire the boldness and general soundness of his views in respect to the classification of *Compositæ* and the limitation of the genera. The plates are by Riocreux, one of the best of living botanical draughtsmen.

A. G.

8. *Manual of the Botany of the Northern United States: Second Edition; including Virginia, Kentucky, and all East of the Mississippi: arranged according to the Natural System;* by ASA GRAY, Fisher Professor of Natural History in Harvard University. New York: 1856. George P. Putnam & Co.—The cultivators of "the amiable science," in the Northern, Middle and Eastern States of our great confederacy, are deeply indebted to Professor GRAY, for this second and more comprehensive edition of his excellent *Manual*. It is just such a *Vade mecum* as the herborizers and young Botanists, of the region indicated, have long needed and earnestly desired. The student is not only sure to find in it, an exact description of all the known plants belonging to the "cooler-temperate vegetation" of the Union, but he finds them arranged in accordance with the principles of the most approved Natural Method,—systematically exhibiting the essential characters, and structural affinities, of the multiform Groups and Families. An artificial *Key* to the Natural Orders is also prefixed, by which the generic name of each plant and its place in the system may be readily ascertained.

It is always a real comfort, as well as a positive encouragement to the practical herborizer, to know that he possesses a work in which he may certainly find a reliable account of every indigenous and naturalized plant within the designated geographical limits; and with such an aid at command no young person properly instructed, or animated by the spirit

becoming an American citizen, should be held excusable for continuing in ignorance of the vegetation around him.

This *Manual* will of course become the constant companion of all intelligent investigators of Plants within the limits referred to: but it ought, also,—in connection with the Botanical *Text-Book*, and elementary *Lessons*, by the same author—to be introduced into every well-ordered seminary (by all means including the common schools,) of the same region. With such class books, in place of the superficial and defective compilations heretofore too generally employed, a just conception of the science would soon supercede the prevalent smattering of uncouth terms destitute of ideas; and a proper foundation would be laid in the inquiring minds of youth for a future superstructure of true Botanical knowledge.

A reform of this character is a consummation devoutly to be wished. It is, indeed, high time that the intellect of "Young America,"—in every educational department—should be placed on the right track at the start, and be so developed, in its progress, as to eschew the vulgar errors and exploded fallacies of the past. The morning of life is too short, and too precious to be wasted in acquiring ideas that are obsolete, and which, of necessity, must be afterward unlearned, or discarded.

In the confident expectation that other editions of the *Manual* will ere long be demanded, we would respectfully suggest to the accomplished and indefatigable Author, the propriety of so extending the future ones, as to comprise all the known Plants of the United States,—and thus present a valuable and most desirable compendium of the Botany of our whole country. While it would meet an urgent present want, it would serve as an exceedingly interesting *Prodromus* of that complete *National Flora*, which must one day be prepared. Such a *Prodromus*—in appropriate type—would form a couple of volumes of very convenient size; the first of which might contain the *Exogenous* Plants of the Union, and the second, the *Endogens* and *Cryptogams*. May we not hope that such a *desideratum* will speedily be supplied? W. D.

9. *Report on the present State of our Knowledge of the Mollusca of California;* by Rev. P. Carpenter, (Proc. Brit. Assoc., August, 1856; Ath., No. 1504.)—As many of the shells of California extend to Sitka, and some even to the Shantar Islands, while the shells of the *Gulf of California* belong to the Fauna of Panama and Ecuador, this report embraces the shells of the whole of the west coast of North America. The causes of error, both in ascertaining the habitat and in identifying the species of mollusks, were pointed out. An historical account was given of all the known collectors in the district, pointing out the degree of authority attached to each, with a list of species, references, synonyms, &c. Special attention had been paid to the minuter shells of the Gulf, among which were pointed out several new and interesting forms. The large multitudes of shells from that district which had been lately sent to this country had brought to light many interesting points concerning the great variations in particular species. In the genus Cæcum, for instance, five species had been made out of different stages of growth in the same shell. All the known shells of which the exact locality was ascertained had been tabulated in columns, representing the distribution of the species, and arranged zoologically. About 800 species are known from the

Gulf, and 625 from Panama, of which 218 are already known to be common to the two—eighty-nine being common to the Gulf and South America and twenty-three to the Gallapagos, which islands have very little in common with South America, more with Panama, and some little with the Indo-Pacific province. The Proboscidifera were found much more local than the rest of the Gasteropods, and these than the Bivalves, the spawn of which latter are borne through wide ranges by the currents. The Fauna of Upper California, as shown by the collections of Mr. Nuttall and the United States Exploring Expedition, are quite distinct from those of the Gulf; scarcely a score of species, and those in very limited numbers, are found in common. Very little is accurately known of the Fauna of the Peninsula. The shells on the Gulf side are, however, mainly Panamic, on the Pacific side, Californian. Scarcely a single species is common to West America and Polynesia, while not a few appear identical with West Indian forms, especially in the Gulf. Several forms reappear on the Gambia coast. A very few reach Britain, chiefly nestling bivalves. The main object of the report was to reduce to a common estimate all that was yet known on the subject, that future students might not have to go over the same ground continually, and to point out the causes of the present very unsatisfactory state of the science, as the first step towards their removal.

10. *On the Vital Powers of the Spongiadæ;* by Mr. Bowerbank, (Proc. Brit. Assoc., August, 1856; Ath., No. 1505.)—The greater portion of these observations were made on a new species of sponge, of a deep orange color, that abounds on the rocks in the vicinity of Tenby between high and low water marks, and which he has named *Hymeniacidon caruncula.* He found that while in a state of repose oscula could rarely be seen in the open state, but immediately after being placed in fresh sea-water these organs were very shortly fully expanded, and streams of water were ejected from them with considerable force; this action continued for a longer or shorter period at the will of the animal, and its termination was sometimes abrupt and at other times very gradual. After the action had ceased for a short period it might again be readily stimulated to a renewal by a supply of fresh cold sea-water, and especially if poured on to the sponge with some degree of force. The action of the oscula were not simultaneous in all parts of the same specimen, and it frequently occurred that while one group were vigorously in action another group were in complete repose. The aspect of the oscula also varied considerably,—sometimes the membranous margins were projected in the form of short tubes, while at other times they were contracted laterally so as to form a tense horizontal membrane, with a widely-expanded central orifice. The author also found the reparative powers of this species remarkably active. If the sponge was cut into three pieces, and these were again brought in contact, in less than twelve hours they became firmly re-united,—and specimens of the same species placed in close contact were united to each other in a few hours, becoming one sponge. The author, in conclusion, briefly referred to the nutritive apparatus of the Spongiadæ. He stated that nearly the whole of the interior of the animal is one large stomachal cavity, furnished abundantly with membranes covered with a coat of sarcode, similar in every respect to the mucous lining of the intestines of

the higher animals, and performing for the sponge precisely the same functions that are exerted from *Actinophrys Sol* upwards, through every gradation of animal existence, to man and the rest of the most elaborately constructed animals. This extraordinary substance, designated in *Actinophrys Sol* as sarcode by Kölliker, and in the higher animals known by anatomists as the mucous lining of the intestines, is apparently an organ of very much more importance in the process of digestion than has been generally conceived. In the Spongiadæ there is every reason to believe that the imbibition of the molecules by this substance is precisely in the manner described by Kölliker in *Actinophrys Sol*,—and from the examination of the mucous membranes of animals of every class, the author feels persuaded that the mucous lining in such animals is truly the homologue of the sarcode in the *Actinophrys Sol* and in the Spongiadæ.

11. *Gar-pikes.*—Mr. J. E. Gavit exhibited to the American Association at Albany a vase containing young gar-pikes 4 to 6 inches long from Lake Ontario, which called forth some remarks from Prof. Agassiz. The point of special interest in these representatives of the ancient Ganoids, was the occurrence of an upper lobe to the caudal fin *containing the prolonged vertebral column.* It was placed directly above that fin, was of equal length and had a lanceolate form; it moreover had a peculiar rapid vibratile motion. The vertebral column was continued in it quite to its extremity. These young fishes therefore were essentially indentical in their tails with the Palæozoic species, and in one genus of the Old Red Sandstone, named *Glypticus*, as stated by Prof. Agassiz, the tail was similar in the form of the lobes. This supernumerary lobe disappears as the fish grows older. Prof. Agassiz observed that this was among the many facts which show that the order of succession of animals in past time is exemplified now in the development of individuals. He also remarked on the fact that these Ganoid fishes resemble reptiles in the power of moving the head on the back bone (owing to the ball and socket joint of the vertebræ), and in the *quasi* tail.

## IV. ASTRONOMY.

1. *New Planets.*—The number of asteroidal planets now known is *forty-two.*

*Harmonia* (40) was discovered Mch. 31, 1856, by *Mr. Hermann Goldschmidt*, at Paris. In apparent brightness it equaled a star of the 9–10th magnitude.

The following elements of this planet are computed by Mr. C. F. Pape, of Altona.

Epoch, 1856, May 1,45198 M. T. Berl.

| | | | | |
|---|---|---|---|---|
| Mean anomaly, | 193° | 8′ | 43″·3 | |
| Long. of perihelion, | 10 | 45 | 38 ·2 | Mn. Eqnx. |
| " " asc. node, | 93 | 8 | 17 ·6 | Jan. 0, 1856. |
| Inclination, | 4 | 17 | 3 ·2 | |
| Angle of excentricity, | 2 | 45 | 11 | |
| Log. semi-axis major, | 0·355603 | | | |
| Log. mean daily motion, | 3·016603 | | | |

[*Astr. Nach.*, No. 1022.

2. *Daphne* (41) was discovered May 22, 1856, by *H. Goldschmidt*, at Paris. It was then about as bright as a star of 11–12th magnitude.

3. *Isis* (42) was discovered May 23, 1856, by Mr. *Pogson*, first Assistant at the Radcliffe Observatory, Oxford, Eng. It was then rather brighter than a star of the 10th magnitude.

From the observations of May 28th and June 1st at Oxford and June 9th at Berlin, Mr. C. F. Pape has computed the following elements:

Epoch, 1856, June 9,52295, M. T. Berl.

| | | |
|---|---|---|
| Mean anomaly, | | 311° 19′ 21″·9 |
| Long. of perihelion, | | 310 35 34 ·9 } Mn. Eqnx. |
| " " asc. node, | | 85 13 31 ·3 } Jan. 0, 1856. |
| Inclination, | | 8 8 36 ·6 |
| Angle of excentricity, | | 7 45 47 ·3 |
| Log. semi-axis major, | | 0·359801 |
| Log. mean daily motion, | | 3·010306 |

[*Astr. Nach.*, No. 1031.

## V. MISCELLANEOUS INTELLIGENCE.

1. *American Association for the Advancement of Science.*—The Tenth Meeting of the American Association commenced at Albany on Wednesday the 20th of August last. Prof. James Hall of Albany was President of the year. The local committee of the city had made liberal and well-appointed arrangements for the occasion, and during the sessions devoted themselves most attentively to the interests of the Association, calling forth at the close a unanimous and hearty vote of thanks. The legislative halls of the State Capitol were thrown open for the meetings, and the whole building, and also the new and spacious Geological Hall, for generous evening entertainments. The citizens of Albany in various ways expressed a welcome to the Association, giving free invitations to places of public interest, besides opening their houses to many of its members, and inviting all to evening levees. This hospitality has followed the Association since its formation, wherever it has met, but no place has exceeded the very liberal arrangements made at Albany.

The meeting was in keeping with the munificence of the city, being by far the largest that has been held, numbering among its members some from places a thousand miles off to the south and west, as well as a deputation from Canada. And if there were not a large number from Europe also, it was through no want of effort and liberality on the part of the Albanians, or of free passages offered by the steamships and packets of the Atlantic.

The sessions continued till Thursday morning, the 28th, when the Association adjourned to meet on the 12th of August, 1857, at Montreal, in compliance with an invitation from the City Council and Natural History Society of that City. The officers appointed for the ensuing year are Prof. J. W. Bailey of West Point, *President;* Prof. A. Caswell of Providence, *Vice-President;* Prof. John LeConte of South Carolina, *General Secretary;* and Prof. J. Lovering, of Cambridge, was continued as *Permanent Secretary.*

In addition to the usual sessions of the Association there were two exercises of extraordinary character, and indeed of extraordinary interest for the country. On Wednesday, the 27th, the inauguration of the State Geological Hall took place. The geological collections, owing to their extent, and their comprising the vouchers of the Geological Reports of the State Survey and especially of the Palæontological volumes by Prof. Hall, have a more than American importance.

The great address of the occasion was delivered by Prof. Agassiz, in which he ably sustained the view, that "nature can only be the work of an intellectual Being,—of Mind,—of an Individual God." Remarks were also made by Professors Dewey and Hitchcock, on the history of geological surveys in the United States; by Sir William E. Logan, on the importance of the results of the Geological Survey of New York to Canada and the world; Professor Henry, on the liberality of the citizens of Albany; President Anderson of Rochester University, on the dignity and value of Science; Prof. Chas. E. Davies of Fishkill, on the true practical as the result of an antecedent ideal; and Rev. Dr. Cox on the connection of Religion with Science.

A merited tribute was paid to the memory of the Dr. T. Romeyn Beck, of Albany and resolutions of respect to his memory were passed by silently rising.

On the following day, Thursday, there was the inauguration of the Dudley Observatory when Hon. Edward Everett delivered to an audience of five thousand, an oration of great power, admirably adapted to the occasion.

The Dudley Observatory originated in the munificence of Mrs. Dudley of Albany, lady of the late Charles E. Dudley of that city, formerly member of Congress. During the meeting a letter from Mrs. Dudley was read announcing the additional gift of $50,000 to the Observatory fund towards which Mrs. Dudley had before given $25,000.

It was also stated that through the generous pledges of support on the part of twelve citizens of Albany, Gould's Astronomical Journal would hereafter be published at Albany. Dr. B. A. Gould has in charge the completion of the Observatory and the ordering of its instruments, part of which are already supplied; and under his auspices, if the endowment reaches the amount required for action, Albany will have, as we believe, an Observatory unsurpassed in the land.* It has already proposed to supply the city and shipping of New York with astronomical time.

From the address of Hon. Edward Everett, we cite a single eloquent passage on Galileo.

Galileo.—"On this great name, my Friends, assembled as we are to dedicate a temple to instrumental astronomy, we may well pause for a moment.

"There is much, in every way, in the city of Florence to excite the curiosity, to kindle the imagination, and to gratify the taste. Sheltered on the north by the vine-clad hills of Fiesole, whose cyclopean walls carry back the antiquary to ages before the Roman, before the Etruscan power, the flowery city (Fiorenza) covers the sunny banks of the Arno with its

* Since the adjournment of the Association we learn of the gift towards the Observatory of $10,000 by T. W. Olcott, Esq., of Albany.

stately palaces. Dark and frowning piles of mediæval structure; a majestic dome, the prototype of St. Peter's; basilicas which enshrine the ashes of some of the mightiest of the dead; the stone where Dante stood to gaze on the Campanile; the house of Michael Angelo, still occupied by a descendant of his lineage and name, his hammer, his chisel, his dividers, his manuscript poems, all as if he had left them but yesterday; airy bridges, which seem not so much to rest on the earth as to hover over the waters they span; the loveliest creations of ancient art, rescued from the grave of ages again to enchant the world; the breathing marbles of Michael Angelo, the glowing canvas of Raphael and Titian, museums filled with medals and coins of every age from Cyrus the younger, and gems and amulets and vases from the sepulchers of Egyptian Pharaohs coëval with Joseph, and Etruscan Lucumons that swayed Italy before the Romans; libraries stored with the choicest texts of ancient literature; gardens of rose and orange, and pomegranate, and myrtle,—the very air you breathe languid with music and perfume;—such is Florence. But among all its fascinations, addressed to the sense, the memory, and the heart, there was none to which I more frequently gave a meditative hour during a year's residence, than to the spot where Galileo Galilei sleeps beneath the marble floor of Santa Croce; no building on which I gazed with greater reverence, than I did upon the modest mansion at Arcetri, villa at once and prison, in which that venerable sage, by command of the Inquisition, passed the sad closing years of his life. The beloved daughter on whom he had depended to smooth his passage to the grave, laid there before him; the eyes with which he had discovered worlds before unknown, quenched in blindness:

> Ahime! quegli occhi si son fatti oscuri,
> Che vider più di tutti i tempi antichi,
> E luce fur dei secoli futuri.

That was the house, 'where,' says Milton (another of those of whom the world was not worthy), 'I found and visited the famous Galileo, grown old—a prisoner to the Inquisition, for thinking on astronomy otherwise than as the Dominican and Franciscan licensers thought.'* Great Heavens! what a tribunal, what a culprit, what a crime! Let us thank God, my Friends, that we live in the nineteenth century. Of all the wonders of ancient and modern art, statues and paintings, and jewels and manuscripts,—the admiration and the delight of ages,—there was nothing which I beheld with more affectionate awe than that poor, rough tube, a few feet in length,—the work of his own hands,—that very 'optic glass,' through which the 'Tuscan Artist' viewed the moon,

> 'At evening, from the top of Fiesole,
> Or in Val d'Arno, to descry new lands,
> Rivers, or mountains, in her spotty globe.'

That poor little spy-glass (for it is scarcely more) through which the human eye first distinctly beheld the surface of the moon—first discovered the phases of Venus, the satellites of Jupiter, and the seeming handles of Saturn—first penetrated the dusky depths of the heavens—first pierced the clouds of visual error, which, from the creation of the world, involved the system of the Universe.

* Prose Works, vol. i, p. 213.

"There are occasions in life in which a great mind lives years of rapt enjoyment in a moment. I can fancy the emotions of Galileo, when first raising the newly-constructed telescope to the heavens, he saw fulfilled the grand prophecy of Copernicus, and beheld the planet Venus crescent like the moon. It was such another moment as that when the immortal printers of Mentz and Strasburg received the first copy of the Bible into their hands, the work of their divine art; like that when Columbus, through the gray dawn of the 12th of October, 1492, (Copernicus, at the age of eighteen, was then a student at Cracow), beheld the shores of San Salvador; like that when the law of gravitation first revealed itself to the intellect of Newton; like that when Franklin saw by the stiffening fibers of the hempen cord of his kite, that he held the lightening in his grasp; like that when Leverrier received back from Berlin the tidings that the predicted planet was found.

"Yes, noble Galileo, thou art right, *E pur si muove.* "It does move." Bigots may make thee recant it; but it moves, nevertheless. Yes the earth moves, and the planets move, and the mighty waters move, and the great sweeping tides of air move, and the empires of men move, and the world of thought moves, ever onward and upward to higher facts and bolder theories. The Inquisition may seal thy lips, but they can no more stop the progress of the great truth propounded by Copernicus, and demonstrated by thee, than they can stop the revolving earth.

"Close now, venerable sage, that sightless, tearful eye; it has seen what man never before saw—it has seen enough. Hang up that poor little spy-glass—it has done its work. Not Herschell nor Rosse have, comparatively, done more. Franciscans and Dominicans deride thy discoveries now; but the time will come when, from two hundred observatories in Europe and America, the glorious artillery of science shall nightly assault the skies: but they shall gain no conquests in those glittering fields before which thine shall be forgotten. Rest in piece, great Columbus of the heavens—like him scorned, persecuted, broken-hearted!—in other ages, in distant hemispheres, when the votaries of science, with solemn acts of consecration, shall dedicate their stately edifices to the cause of knowledge and truth, thy name shall be mentioned with honor."

We give below a list of papers presented to the Association at their meeting. Abstracts are not here published, unless contributed by the authors, as we hold that an author should have the responsibility of presenting his own views in a Scientific Journal.

### I. *Section of Mathematics, Physics and Chemistry.*

The Elements of Potential Arithmetic; by Prof. Benjamin Peirce.

On the Next Appearance of the Periodical Comet of thirteen years; by Dr. Peters.

On Ammonia in the Atmosphere; by E. N. Horsford.

On a Possible Modification of the methods of ascertaining the density of the earth; by Stephen Alexander.

Investigation and Calculation of the results of a general process of causation; by John Patterson.

On the Law of Human Mortality; by C. F. M'Coy.

Analytical Discussion of the motion of a body under the action of central forces; by Benjamin Peirce.

On Acoustics as applied to public buildings; by Prof. Henry.

Notes on the Progress made in the Coast Survey, in prediction tables for the tides of the Coast of the United States; by A. D. Bache.

On the History and Theory of the instruments known as rotascopes, gyroscopes, etc.; by W. B. Rogers.

On Various Cyclones or Typhoons of the North Pacific Ocean, with a chart showing their course of progression; By W. C. Redfield.

On the Modifications of the Sesquioxyd of Chromium; by E. N. Horsford.

On the Relative Age of the different portions of the moon's surface, and the catastrophe to which a large portion seems to have been subjected; by Stephen Alexander.

On a New Method of measuring celestial arcs; by Alvan Clark.

Approximate cotidal lines of diurnal and semidiurnal tides of the Coast of the United States on the Gulf of Mexico; by A. D. Bache.

A Report on the New Methods of Observation now in use at the Cincinnati Observatory; by O. M. Mitchell, viz:

1. New Method of right ascension, as to its limit of accuracy.
2. New Method of declination, as to its limit of accuracy.
3. New Method of determining personal equation and personal error.
4. New Method of determining instrumental errors.
5. New Method of determining clock errors.
6. Observations on changes of figure of materials.

Morphological discussion of the laws of central forces; by Benjamin Peirce.

Further Investigation relative to the form, the magnitude, the mass, and the orbit of the asteroid planets; by Stephen Alexander.

On the Heat in the Sun's rays; by Elisha Foote.

On the Heat in the Sun's rays; by Eunice Foote.

Tidal Currents of Saturn's Ring; by Benjamin Peirce.

Remarks on Ozone observations; by W. B. Rogers.

On the Meridian Instruments of the Dudley Observatory; by B. A. Gould.

On some Special Arrangements of the Solar System, which seem to confirm the nebular hypothesis; by Stephen Alexander.

Notice of Ooservations to determine the cause of the increase of Sandy Hook, made by the Coast Survey, for the Commissioners on harbor encroachments of New York; by A. D. Bache.

On the Advantage of observing a lunar spot instead of a limb, in transits, for determining the difference of longitude; by Dr. Peters.

Supplement to the Paper published in the Providence Proceedings, on the secular variation in magnetic declination in the Atlantic and Gulf Coast of the United States, from observations in the 17th, 18th, 19th centuries, under permission of the Superintendent; by Charles A. Schott.

Discussion of the Secular variation of magnetic inclination in the Northeastern States, communicated under permission of the Superintendent and authority of the Treasury department; by Charles A. Schott.

Discussion of the terrestrial magnetic elements for the United States, from observations in the Coast Survey and others; by A. D. Bache and J. E. Hilgard.

On Temporary Stars, and the spheroidal origin of the forms of clusters and nebulæ; by Stephen Alexander.

On the formation of air bubbles by drops falling on the surface of water, etc.; by William B. Rogers.

On the Results of the United States Astronomical Expedition to Chili, for the determination of the solar parallax; by B. A. Gould, Jr.

An Account of a large barometer in the Hall of the Smithsonian Institution; by Joseph Henry.

On a Method of determining the latitude of a place, from the observed times when two known stars arrive at the same altitude; by W. Chauvenet.

On the Plan of Reduction of the Meteorological Observations reported to the Smithsonian Institution, adopted by the Secretary; by James H. Coffin.

On Tables of the Asteroids; by Dr. Brünnow.

Tables of Prussian Mortality, interpolated for annual intervals of age; accompanied with formulæ and process for construction; by E. B. Elliott.

Process for deducing accurate average duration of life, present values of life annuities, and other useful tables involving life contingencies from returns of population and deaths, *without the intervention of a general interpolation;* by E. B. Elliott.

On the Increase of Accuracy in the mean result, by augmenting the number of observations; by Dr. Peters.

On the Stability of satellites revolving in narrow orbits; by Daniel Vaughan.

Researches on the ammonia-cobalt bases; by Dr. Wolcott Gibbs and Dr. F. A. Genth.

On the Production of Rotary Currents in air and other gases, with a special illustration of a rotary current rendered luminous by flame and incandescent charcoal; by Dr. D. B. Reid.

On the Altitude and Physical Structure of the Appalachian System in the Region of the Black Mountains in North Carolina, compared with those of the White Mountains in New Hampshire; by A. Guyot.

On Some Experiments on visual direction; by John Brocklesby.

On the Phenomena of the discharge of ordinary electricity; by Joseph Henry.

Redetermination of the atomic weight of lithium; by J. W. Mallett.

Account of the Typhoon of October 28, 1854, at the Bonin Islands; with a sketch of its barometric curve, and notices of other cyclones; by John Rogers, *Com. U. S. Navy:* Communicated by W. C. Redfield.

Whirlwind and Tornado vortices; by W. C. Redfield.

Motion of a Body upon a solid of revolution, when the force is directed towards a point upon the axis; by Benjamin Peirce.

On the Physical Peculiarities of Comets; by Stephen Alexander.

A Simple Method of correcting the common nautical method of "double altitudes" of the sun, moon, or a planet, for the change of declination between the observations; by W. Chauvenet.

On the annual duration of sunlight on the earth in different latitudes; by L. W. Meech.

Researches concerning the Comets of 1783 and 1793; by Dr. Peters.

The Fundamental numeric series, and divergence of radiating parts, reduced to a simple organological idea; by Dr. T. C. Hilgard.

Note on the Rotation of a rigid body; by J. B. Cherriman.

On the Interpretation of some Cases of apparent geometric discontinuity; by J. B. Cherriman.

On the Forms of the Atoms of the simple substances of chemistry, as indicated by their atomic weights; by Stephen Alexander.

On the Meteorological Phenomena during the epidemic of 1855 at Portsmouth, Va.; by Nathan B. Webster.

On the Modification of Noremburg's Apparatus by about 4 or 5 minutes; by Sanderson Smith.

On the waters of the St. Lawrence and the Ottawa rivers; by T. Sterry Hunt.

On Efflorescence from brick masonry; by E. B. Hunt.

Report on the Observatory of Toronto; by J. B. Cherriman.

Results of a Series of Meteorological Observations made at New York Academies from 1825 to 1850 inclusive; by Franklin B. Hough.

Remarks on the Use of the aneroid barometer; by A. Guyot.

Experiments on the nozzles of blowing apparatus, made at the Smithsonian Institution; by Thomas Ewbank.

## II. *Section of Natural History and Geology.*

On the Volcanic Phenomena of Kilauea and Mauna Loa; and on the dynamical theories of earthquakes, etc.; by C. F. Winslow.

On Volcanoes; by C. F. Winslow.

Exhibition of living Gar-pikes; by J. E. Gavit.

Notes on the Geology of Middle and Southern Alabama; by A. Winchell.

Parallelism of Rock Formations in Nova-Scotia, with those of other parts of America; by J. W. Dawson.

Proof of the Protozoic Age of some of the altered rocks of Eastern Massachusetts, from fossils recently discovered; by W. B. Rogers.

On Carboniferous Reptiles; by Jeffries Wyman.

Permian and Triassic Systems of North-Carolinia; by Ebenezer Emmons.

General Description of the Boundary Line between the United States and Mexico; with General Notices of the topography, geology, agricultural resources, etc. of the country adjacent; by W. H. Emory.

Some Points in the Geology of the Upper Mississippi Valley; by James Hall.

On the Plan of Development in the Geological History of North America; by James D. Dana.

On the Geological Position of the Fossil Elephant of North America; by J. W. Foster.

On the Geology of the Broadtop Coal Region in Central Pennsylvania; by J. P. Lesley.

On the Orography of the western portion of the United States, with a map; by William P. Blake.

Description of a Fossil Shell found in the Sandstone of the Connecticut River Valley; by E. Hitchcock.

Sketch of the Progress of Geology in Alabama; by Michael Tuomey.

Notice of a Remarkable Instance of inclined stratification in Warren county, N. Y.; by J. D. Whitney.

On the Deposits of the fossil fishes and reptiles of Linton, Ohio; by J. S. Newberry.

On the Organization of Acanthocephala; by Dr. Weinland.

On Animal Development; by Louis Agassiz.

On some Euphotides, and other felspathic rocks; by T. Sterry Hunt.

On the Serpentines of the Green Mountains, and some of their associates; by T. Sterry Hunt.

Exhibition of Fossil Fish Remains from the Carboniferous limestones and Coal measures of Illinois; by A. H. Worthen.

Generalities of the Geology of Oregon and Northern California; by J. S. Newberry.

On the Carboniferous limestone of the Mississippi Valley; by James Hall.

Geological Observations on the Philo-volcanic Slope of the Mountains of Sonora near the Boundary, made under the direction of W. H. Emory, U. S. Commissioner; by Arthur Schott.

Exhibition of Fossil Cetacea from Maine; by A. C. Hamlin.

On Fossil Wood with structure, found by Sir W. E. Logan in the Devonian rocks of Gaspé; by J. W. Dawson.

On the Agency of the Gulf-Stream in the formation of the Peninsula and Keys of Florida; by Joseph Leconte.

Observations on the Geology of the Region between the Mississippi and the Pacific Ocean, with a Map; by Wm. P. Blake.

Review of a Portion of the recent Geological Map of the United States, published in Europe by Jules Marcou; by Wm. P. Blake.

Some Observations on the Coal fields of Illinois; by R. P. Stevens.

Mud-nests of the Tadpole, recent and fossil; by Edward Hitchcock.

Origin and Age of the red loam of Alabama, with a notice of some *loess* deposits; by A. Winchell.

So-called Human Petrifactions, by Trail Green; read by H. J. Coffin.

On the influence of light and water on the direction of the plumule and radicle in the germination of plants; by James Dascomb.

Viviparity and Oviparity; by Louis Agassiz.

On the Absence of trees from prairies; by Daniel Vaughan.

On the Classification of Turtles; by Louis Agassiz.

On the Relation of the Post-Permian Fishes of Connecticut and other Atlantic States, to the Triassic and Jurassic periods; by J. H. Redfield and W. C. Redfield.

On the Results of Collections of fossils during a period of ten years in the limestones of the Lower Helderberg; by James Hall.

The Metamorphic action of silicious thermal springs; by J. S. Newberry.

The Tertiary Flora of the Upper Missouri; by J. S. Newberry.

Statistics of some Artesian Wells of Alabama; by A. Winchell.

## III. *Ethnology.*

On the Names of Animals, with reference to Ethnology; by Dr. Weinland.

On the Relations between Chinese and Indo-European Languages; by S. S. Haldeman.

On the Structure of the Algonquin Language; by Henry R. Schoolcraft.

Supposed Runic Inscriptions from the Coast of Maine; by A. C. Hamlin.

On the Value of the Physical conformation as an element of ethnological science; by Daniel Wilson.

Queries relative to some indications of human instinct, as illustrated by primitive arts; by Daniel Wilson.

Considerations upon the evidences of the early voyages of the Scandinavians to this Country, and upon the cosmical myths supposed to relate to America; by A. C. Hamlin.

2. *The Meteor of July 8th;* by W. Spillman.—Since the appearance of the large meteor on the evening of the 8th of July, I have endeavored to collect all the information I could respecting it: and as I did not see it myself, I have had to rely entirely on information obtained from others, and was thereby, at first, led into an error both as regards its angle of altitude, and the direction in which it was seen from this place. It was my first impression, (and I so expressed myself verbally, and by letters to others,) that its first appearance was, at an angle of 35° above the horizon, north-northwest of Columbus. To be more definite in its direction from this place, I took with a compass both its direction and altitude, as pointed out by Dr. Hopkins who saw it from a favorable position to observe. From the course pointed out by Dr. Hopkins, the meteor could not have been more than 20° north of northwest, nor at a greater altitude than 30° at its first appearance. Its approach toward the earth as seen from Columbus, as far as I can learn, was apparently a little north of where it first became visible; and the time that intervened between its explosion and the rumbling noise afterwards heard, was about three minutes; this however, must be considered as only an approximation, as I have seen no one who observed the time by a clock or watch:—besides, if Professor Harper be correct in his statement, that the meteor approached the earth in a northeast direction from where he observed it, four miles south of Grenada, its line of approach could not have been nearer to Columbus than sixty-two miles, which would have required about $4\frac{3}{4}$ minutes after its explosion for the sound to reach here, even when a due allowance is made for the course and force of the wind on that evening, which was from the northwest, at the rate of four miles an hour as registered by J. S. Lull, Esq., of this place, in his meteorological table.

Prof. Harper, who was four miles south of Grenada at the time of the appearance of the meteor, states in a paper published in the Memphis Appeal, that five minutes intervened between the visible explosion and the rumbling noise, consequently the explosion must have been sixty-eight miles from where he was. The meteor therefore must have been very high when it exploded, if the fragments reached the earth at or near the place designated by him, which was the south-west corner of Pontotoc, adjoining portion of Calhoun or Lafayette county, which would only be from forty to fifty miles from where he was at the time the meteor appeared. Admitting then that Prof. Harper was correct in his calculation, that the meteor approached the earth in a northeast direction from where he was, and also as seen from Columbus at an angle of 30° above the horizon, it must have been at least thirty-six miles high. At Holly Springs I learn that the meteor appeared a little east of south, and at an altitude of about 35° above the horizon, and as Holly Springs is about forty-six

miles from the line, or course of the meteor as above noticed, it would make it about thirty-two miles high.

Again admitting that the meteor when seen by Prof. Harper, was fifty miles northeast of his point of observation, and 35° above the horizon, it must have been about thirty-five miles high. Taking then the course of the meteor as indicated by Prof. Harper, as a base line, we may safely conclude that it was at least thirty miles high when it first became visible. As to its distance from the earth at the time of the explosion, I have no data to found a calculation upon. Prof. Harper however, says, "it could not have been much above the clouds."

As to where this meteorite found a resting place on *Terra Firma*, after its countless revolutions around it, for centuries past, would be a difficult task, unless some one was fortunate enough to have seen or heard it strike our globe.

We might, however, be aided very much in our search for it, if those who saw it under favorable circumstances would take the course in which they saw it, with a compass, and communicate the same to Prof. Harper, at Oxford, together with the altitude above the horizon in which they saw it, and as near as possible the time that intervened between its first appearance and the rumbling noise that followed. The writer of this article would also thankfully receive any information that any one may see proper to communicate to him, respecting the meteor under consideration.—*Columbus (Miss.) Democrat.*

Columbus, Miss., Sept. 1st, 1856.

3. *Sulphuric Acid Barometer.*—Professor Henry stated to the Association at Albany, that a barometer filled with sulphuric acid had been made for the Smithsonian Institution. The objection from its affinity for moisture is avoided by using a drying tube apparatus containing chlorid of calcium for drying the air that comes in contact with the acid. The tube is 240 inches long and three-fourths of an inch in diameter, and is inclosed in a glass case 2½ inches in diameter. The construction was entrusted to Mr. James Green of New York.

4. *Cantonite.*—A mineral with the composition of Covelline, but a *monometric form*, has been named Cantonite by Mr. N. A. Pratt. A description of the species by Mr. Pratt will appear in our next.

5. *British Association.*—The Twenty-sixth meeting of the British Association was held this year, at Cheltenham, commencing with August 6th. The presidential address at its opening was delivered by Professor Daubeny, President of the meeting.

6. *American Geological History.*—In connection with the article, page 335, it should have been stated that the paper was read at the Meeting of the American Association at Albany in August last.

7. Obituary.—*Rev. Dr. Buckland.*—Few men have filled a wider space in public estimation for the last twenty-five years than Dr. Buckland. His name is intimately associated in the popular mind of this country with the progress of geology. He may not have possessed the natural acquirements or the philosophical acuteness of many of his contemporaries; but he possessed a heartiness of spirit, an indomitable energy of purpose, a geniality of character, which rendered him, even amongst men remarkable

for their gifts, the most remarkable. These qualities made Dr. Buckland the most prominent of a band of philosophers who gradually worked their way in geological science, redeeming it from the puerilities of a popular hypothesis, and placing it high amongst the physical sciences. In this great work Buckland was associated with Lyell, De la Beche, Sedgwick, Murchison, Phillips, and Conybeare.

Although we have now to record the death of Dr. Buckland, which took place on Thursday, the 14th inst., at Clapham, yet he had many years closed his scientific career. In the year 1850 his brain gave way under the excessive activity to which it had been exposed, and from that time to this he has never recovered sufficiently to attend to his scientific pursuits.

Dr. Buckland was born at Axminster, in Devon, in the year 1784. He received his early education at Winchester, and in 1801, obtained a scholarship in Corpus Christi College, Oxford. He took his degree of B. A. in 1803, and was elected a Fellow of his College in 1808. At this time Oxford was the most unpromising school in the world for natural science. Nevertheless there were chairs of Botany, Chemistry, and Mineralogy to indicate to the student that all human wisdom was not bound up in Classics and Mathematics. The tastes of young Buckland led him to the study of Mineralogy, and in 1813 we find him appointed to the Readership of Mineralogy, and in 1818 to the Readership of Geology. In these positions he succeeded in attracting attention to the departments of physical science which he taught. But as he excited interest he excited opposition, and every onward step that he made towards giving the science of geology a position in the University, raised an opponent to its claims. Through his long life he had to fight for his science in his Alma Mater. But he gained the victory,—and Strickland and Phillips, his successors, have obtained a universal recognition of the value and importance of their teachings.

In 1820 Dr. Buckland delivered a lecture before the University of Oxford, which was afterwards published under the title of "Vindiciæ Geologicæ; or, the Connection of Religion with Geology explained." In this work he showed that there could be no opposition between the works and the word of God, and that the influence of the study of natural science, so far from leading to atheism and irreligion, necessarily led to the recognition of God and to his worship. At this time, however, Dr. Buckland still adhered to the old hypothesis of the universality of the Deluge. He, however, became convinced of the untenability of this position, and in his Bridgewater Treatise, published in 1836, entitled "Geology and Mineralogy considered in reference to Natural Theology," we find him adopting the views of Lyell and others.

Dr. Buckland's name will ever be associated in this country with his discoveries of the remains of animals in the caves of Kirkdale, and other parts of England. Of these discoveries he first gave an account in the *Philosophical Transactions* in a paper, entitled "Account of an Assemblage of Fossil Teeth and Bones of Elephant, Rhinoceros, Hippopotamus, Bear, Tiger, and Hyæna, and Sixteen other Animals, discovered in a Cave at Kirkdale, Yorkshire, in the year 1821." These discoveries and others served as a basis for a work published in 1823, entitled "Reliquiæ Diluvianæ; or, Observations on the Organic Remains attesting the Action of an Universal Deluge." Although the occurrence of these remains are

now accounted for on a different theory, the great value of this work remains as a record of the first discovery of the remains of animals of which most have since disappeared from the world, and thus revealing the nature of the animal inhabitants of Great Britain previous to the arrival of man. In addition to the above account of the bones of animals found in caves in Great Britain, Dr. Buckland described many from the Continent, as the bones of hyænas found in the cavern of Lemel, near Montpellier, and the bones of bears found in the Grotto of Osselles, or Quingey, near Besançon.

His contributions to the *Proceedings of the Geological Society* were very numerous, and in the first volume of the "Bibliographia Geologiæ et Zoologiæ," published by the Ray Society in 1848, we find references to sixty-one distinct works and memoirs. Dr. Buckland's social habits often led him to work with others. Thus we find him early in his career working out the southwestern coal district of Gayland in company with his friend Conybeare. In conjunction with the same distinguished geologist, he published "Sectional Views of the North-East Coast of Ireland" and "Illustrations of the Landslip on the Coast of Devonshire." With the late Sir H. De la Beche, he published a paper in the *Transactions of the Geological Society* "On the Geology of the Neighborhood of Weymouth." In conjunction with the late Mr. Greenough, he published a paper on "Vitreous Tubes in Sand-hills near Dirg. in Cumberland." With Mr. Sykes, a paper on the interior of the dens of living hyænas. His papers generally display great powers of observation, with unwearied industry; and many of the general conclusions arrived at by the author have now become part and parcel of the great laws of geological science.

In 1825 Dr. Buckland accepted from his college the living of Stoke Charity, near Whitchurch, Hants; in the same year he was promoted to a Canonry in the Cathedral of Christ Church, and married Miss Mary Morland, of Abingdon. In 1818 he had been elected a Fellow of the Royal Society; and in 1829 he was chosen a member of the Council of that body, and was re-elected on each successive occasion till his illness in 1849. In 1813 he became a Fellow of the Geological Society, and was twice elected President of that body. He took an active interest in the formation of the British Association for the Advancement of Science, and was one of those who took the bold step of inviting this body to hold its second meeting in the University of Oxford. On this occasion he was President of the Association. From that time to 1848 he was present at the meetings, and read many of his papers before them.

In 1847 Dr. Buckland was appointed a Trustee of the British Museum, and took an active part in the development of that department more especially devoted to Geology and Palæontology. He also seconded, to the utmost of his power, the efforts of Sir Henry De la Beche to establish the Museum of Economic Geology, which is now, in conjunction with the Government Geological Survey, working so successfully in Jermyn Street as the School of Mines. In 1845 Dr. Buckland received, at the hands of Sir Robert Peel, the Deanery of Westminster, vacated by the present Bishop of Oxford. This brought him to reside in London, where he immediately took a lively interest in all questions involving social amelioration. He exerted himself to gain a more free admission for the public to the Monuments in Westminster Abbey. He joined the

ranks of sanitary reformers, and brought his great knowledge of geology to bear on questions of water supply, sewerage, and other health questions. Dr. Buckland seems not to have devoted himself to questions of technical theology. His views on this subject are chiefly contained in the Bridgewater Treatise and the "Vindiciæ." Among the list of published works we find one sermon, and that devoted to the subject of death: it was published at Oxford in 1839.—*Ath., Aug.* 23, 1856.

8. *Geology of the Pacific and other regions visited by the U. S. Exploring Expedition under C. Wilkes, U. S. N., in the years* 1838–1842; by JAMES D. DANA, Geologist of the Expedition.—This Report consists of a quarto volume of text of 750 pages, illustrated by several maps and numerous wood cuts, and a folio atlas of 21 plates. It treats of the Structure, Growth, and Distribution of Coral Reefs and Islands; of the Geology of the Sandwich Islands; the Society Islands; the Feejees; the Navigators; of the Phenomena of Volcanic Action; Changes of level in the Pacific, and origin of the general features of the Globe; of the Geology of New Zealand, Chili, and Fuegia; and a part of Oregon and California.

The folio atlas contains figures of fossils of the Coal and inferior formations of New South Wales, and of the Tertiary rocks of Oregon.

Only 200 copies of this Government Report have hitherto been printed. The author proposes to have 250 copies published for the benefit of those who are interested in the subjects. The copies will be furnished to subscribers for $12.00, the text bound in cloth, the payment to be made on delivery. A copy was recently sold in New York City for $40.00.

Should the subscription list reach 500, the edition would be increased accordingly, and the price reduced to $10.00. The work, if undertaken, will be ready for delivery in the course of the coming year.

Any person desiring one or more copies, is requested to address the author.

New Haven, October 1st, 1856.

9. *A Chronological Table of Cyclonic Hurricanes which have occured in the West Indies and in the North Atlantic from* 1493 *to* 1855; *with a Bibliographical List of Authorities;* by ANDRÉS POEY, Esqr., of Havana.—Communicated to the British Association by Dr. Shaw. Printed by Clowes and Sons, London, pp. 40.

This pamphlet does credit to the zeal and research of Mr. Poey. It comprises a list of four hundred gales and hurricanes, with summary descriptions and references together with explanatory notes: also, a bibliographical list of four hundred and fifty Authors, Books, and Periodicals, where interesting accounts of hurricanes may be found.

Of the number of hurricanes cited by Mr. Poey as having occurred in the West Indies and Atlantic Ocean, the monthly distribution of three hundred and fifty-five was as follows, viz:

| Months. | No. of hurricanes. | Months. | No. of hurricanes. |
|---|---|---|---|
| January, | 5 | July, | 42 |
| February, | 7 | August, | 96 |
| March, | 11 | September, | 80 |
| April, | 6 | October, | 69 |
| May, | 5 | November, | 17 |
| June, | 10 | December, | 7 |
| | Total, | | 355 |

Mr. Poey considers his table as only a first step to facilitate enquiries on this important subject.

10. *Descriptions of some Remains of Fishes from the Carboniferous and Devonian Formations of the United States, and of some Remains of Extinct Mammalia;* by JOSEPH LEIDY, M.D.—From the Journ. Acad. Nat. Sci. Philadelphia, 12 pp. 4to, with 3 plates.—The Species of Fishes here described, are *Edestus* (Leidy) *vorax*, from the vicinity of the Arkansas 20 miles below Fort Gibson, a gigantic fish related to Carcharodon, a fragment of the jaw of which is 6 inches long; *Oracanthus vetustus*, Leidy, from Missouri; *Petalodus Alleghaniensis*, from Blair Co., Pa.; *Holoptychius Americanus*, Leidy, Tioga Co., Pennsylvania; *Stenacanthus* (Leidy) *nitidus*, same locality as last; *Apedodus priscus*, L., Columbia Co., Pa.—The Mammals, are *Camelops Kansanus*, (Leidy) from the Territory of Kansas; *Canis primævus*, from the banks of the Ohio river a short distance below Evansville, Indiana, associated with *Megalonyx Jeffersonii*, *Bison Americanus*, *Cervus Virginianus*, *Equus Americanus*, and *Tapirus Haysii*;—*Ursus amplidens*, L., from a ravine near Natchez, Mississippi, occurring with *Equus Americanus*, *Cervus Virginianus fossilis*, *Mastodon*, *Megalonyx*, *Mylodon*, *Ereptodon*; *Ursus Americanus fossilis*, from near Natchez; *Procyon priscus*, LeConte, from Galena, Illinois.

11. *The Quarterly Journal of Pure and Applied Mathematics*, edited by J. J. SYLVESTER, M.A., F.R.S., late Professor of Nat. Phil. in University College, London, and N. M. FERRIS, M.A., Fellow of Gonville and Caius College, Cambridge; assisted by G. G. STOKES, M.A., F.R.S., Lucasian Professor of Mathematics in the University of Cambridge, A. CAYLEY, M.A., F.R.S., late Fellow of Trinity College, Cambridge; and M. HERMITE, Corresponding Editor of Paris; 8vo. London: John W. Parker and Son, West Strand; 5*s.* each number.—The first number of this Mathematical Quarterly Journal, was issued in April, 1855. The character of the work may be inferred from the distinguished names constituting its board of Editors. Each number contains 96 pages octavo, and is occupied with papers both in pure mathematics and the applications of mathematics to questions in physics, and the arts.

12. *Fossils of South Carolina;* by M. TUOMEY and F. S. HOLMES. 4to. Charleston, S. C. 1856.—Nos. 7 and 8 of this beautiful work have been issued. The plates are remarkably fine. They represent the species Pecten septenarius, Mytilus incrassatus, M. inflatus, Arca hians, A. incile, A. cœlata, A. centenaria, A. rustica, A. lienosa, A. improcera, A. transversa, A. scalaris, A. equicostata, A. incongrua, A. pexata.

13. *Abhandlungen der Kaiserlich-Königlichen Geologische Reichsanstalt.* II. Band.—4to, with 78 lithographic plates. Wien.—This splendid volume issued by the Royal Geological Society at Vienna, (1855), contains a Geological Chart of the vicinity of Schemnitz, by von Pettko, three papers by Dr. Constantine von Ettingshausen on Fossil Plants, with numerous plates, the first on the Tertiary Flora of the vicinity of Vienna; 2nd, the Tertiary flora of the Tyrol; 3d, the Carboniferous Flora of Radnitz in Bohemia; also a memoir by Dr. J. K. Andrae on the Fossil Flora (Tertiary) of Siebenburg. The third paper by von Ettingshausen, contains among its 29 plates representations of some of the most magnificent coal-plants thus far discovered. There are figures of branches of several Lepidodendra in full foliage, and in one, of the *L. Sternbergii*, the linear or acicular leaves are over a foot long, and form a dense mass about a branch 1½ inches thick, the whole two feet in length.

14. *Geognostiche Darstellung der Steinkohlen-formation in Sachsen mit besonderer Berücksichtigung der Rothliegenden*, von HANNS BRUNO GEINITZ; Erste Abtheilung. 90 pp. fol., with 12 lithographic folio plates. Leipzig, 1856. Verlag von Wilhelm Engelmann.—We recently noticed the beautiful work of Dr. Geinitz on the Fossil Plants of the Coal formation of Saxony. In the work just issued, the author treats of the rocks and coal beds. He first describes the various known kinds of coal from lignite to anthracite and graphite and their modes of occurrence. Next he treats of the Coal formation of the Erzgebirg Basin; (1,) the Hainich-Ebersdorf Coal formation, or the Saxon culm-coal; (2) the productive coal beds of the vicinity of Zwickau; (3,) the Permian with the included eruptive rocks, overlying the coal measures of Zwickau; (4,) on the probable extension of coal to the west and north of Zwickau, and on the explorations for stone coal in the granulite north: with further special remarks on the Erzgebirg basin at Zwickau. Prof. Geinitz then takes up in a following chapter the anthracite region of the Upper Erzgebirg. The descriptions as well as sections exhibit with great precision the order of succession and characters of the beds of rock and coal in the coal measures of the different regions, and many facts bearing on their origin and history. The Permian is shown to be essentially a part of the Palæozoic, related to the Carboniferous Period, rather than to the Triassic.

15. *Das normal Verhältniss der chemischen und morphologischen Proportionen*, von ADOLF ZEISING. 112 pp. 8vo. Leipzig. Rudolf Weigel.—*O Θεὸς γεωμετρεῖ*.—The idea of simple mathematical proportions in nature is exciting much attention and research. M. Zeising in this work endeavors to trace the numbers 1 : 2 : 3 : 5 : 8 : 13 : 21 : 34, etc., which are known to occur in the arrangement of the leaves of plants, through the human figure, animal and vegetable structure, physiology, musical harmony, the planetary system, the earth's features, architecture and chemistry. And he further aims to reduce it to a still simpler form.

He divides 1000 into two parts, in such a way that the *larger* is a mean between the *smaller* and the *whole*, which gives 1000 : 618·0339 : 381·9660. This series continued, by simple proportion, making the first to the second, as the second to the third, the third to the fourth and so on: —gives 1000 : 618·03... : 381·96... : 236·06... : 145·89... : 90·16... : 55·72... : 34·44... : 21·28... : 13·15... : 8·13... : 5·02... : 3·10... : 1·92 ... : 1·18... 0·45... etc., in which the sum of any two adjoining terms equals the next preceding.

In the series $\frac{1}{1}$ $\frac{1}{2}$ $\frac{2}{3}$ $\frac{3}{5}$ $\frac{5}{8}$ $\frac{8}{13}$, etc. the last term has the value 0·618, corresponding with the value of the *larger* of the terms above, and showing that the series is based fundamentally on the preceding. M. Zeising compares the normal height of man (A) with the height of the lower part of the body (B), and of the upper (C), and states the ratio, A : B : C=1000 : 618·0 : 381·9. Again, for the ratio of the whole lower part (A), the upper part of the leg (B), and the lower (C), the ratio A : B : C=618·0 : 381·9 : 236·0. So also for the upper part of the body (A), and its two parts the chest (B), and the head (C), the ratio A : B : C=381·9 : 236·0 : 145·9.—In music, the ratios 1 : 2 : 3 : 5 : 8, are given by the succession of tones C : C (octave) : G : E : C (2nd octave).—1 : 2 is the octave; 2 : 3 the fifth; 3 : 5 major sixth or minor third transposed; 5 : 8 minor sixth, or major third transposed.

For the proportion of land and water on the globe, Rigaud deduced the ratio 100 : 270, and Humboldt, the ration 100 : 280; and this corresponds with $3^2 : 5^2$ which equals 9 : 25 or 100 : 277. The land of the American continents equals 10,606,400 sq. m., and that of the other hemisphere, 27,274,000 sq. m.; the ratio is 1 : 2·57 which equals $5^2 : 8^2$. These are a few examples from the work.

16. *Principles of Chemistry, embracing the most recent discoveries in the Science, and the outlines of its application to Agriculture and the Arts.* Illustrated by numerous experiments newly adapted to the simplest apparatus; by JOHN A. PORTER, M. A., M. D., Prof. Agric. and Organic Chem. in Yale College. 480 pp. 12mo. New York, 1856. A. S. Barnes & Co. —In the preparation of this text-book, Prof. Porter has aimed at a clear, simple and practical presentation of the principles of Chemistry, not overloaded with details, and with such experimental illustrations as may be repeated with simple means, small expense, and little previous knowledge. The plan is well carried out, and the work is an excellent one for classes in Chemistry.

17. *Smithsonian Contributions to Knowledge*, vol. VIII.—*U. S. Naval Astronomical Expedition*, vol. II.—These works were not received in time for a notice in this number.

B. ALVORD: The Tangencies of Circles and of Spheres, by Benjamin Alvord, Major U. S. A.—Smithsonian Contributions to Knowledge. 16 pp. 4to, with 9 plates.

STEENSTRUPP: Hectocotyldannelsen hos Octoposlægterne Argonauta og Tremoctopus, ved Joh. Japetus Sm. Steenstrup. 32 pp. 4to, with 2 plates. Kjobenhavn. 1856.

Ninth Annual Report of the Regents of the University of the State of New York on the condition of the State Cabinet of Natural History and the Historical and Antiquarian Collection annexed thereto. Albany, 1856.

PROCEEDINGS ACAD. NAT. SCI. PHIL., VIII.—p. 101 and 106, Remarks on some Reptiles occurring near Philadelphia; *Hallowell.*—p. 102, Note on the massive spathic iron of the West side of Chesapeake bay, called Baltimore ore; *C. E. Smith.* —p. 103, On four new species of Exotic Uniones; *I. Lea.*—p. 109, Descriptions of three Myriapoda; *A. Sager.*—p. 109, Description of thirteen new species of Exotic Peristomata; *I. Lea.*—p. 111, Descriptions of fossils from the Tertiary of the Upper Missouri, with remarks on the Geology; *F. B. Meek* and *F. V. Hayden, M. D.*—p. 126, Ceratites Americanus, Prof. *L. Harper.*—p. 128, Examination of Meteoric iron from Xiquipilco, Mexico; *W. J. Taylor.*—p. 130, Description of two new species of Urodeles from Georgia; *E. Hallowell, M. D.*—p. 131, Contributions to the Ichthyology of the Western Coast of the United States from specimens in the Museum of the Smithsonian Institution; *C. Girard, M. D.*—p. 138, New Experiments on A. St. Martin, the person experimented on by Dr. Beaumont.

Videnskabelige Meddelelser fra den Naturhistoriske Forening i Kjöbenhavn. 1854. No. 8-12.—Contents: Mexican and Central American Acanthaceæ, with two plates; *A. S. Oersted.*—Plants of the Haunien University, No. 2; *F. Didrichsen.*—On the occurrence of Tin ore and Cryolite in Greenland; *Th. Hoff.*—On the localities of Graphite and Eupyrchroite in the State of New York; *C. Fogh.*—On the Convolvulaceæ from Guinea in the University Museum; *A. Didrichsen.*

*From Th. Kunike, successor to C. A. Koch, Greisswald.*

Der Pithoanische Codex Juvenals. Erster Theil. Kritisch-exegetische Abhandlung, von Dr. A. HÄCKERMANN, Gymnasiallehrer. 40 pp. 4to. Greisswald, 1856. T. Kunike.

Index Scholarum in Universitate Litteraria Gryphisvaldensi, per semestre æstivum Anni MDLCCCLVI, a Die Mensis Aprilis habendarum. T. Kunike.

De Gravidatate Extra-uterina, accedit Descriptio memorandæ cujusdam Graviditatis Tubæ Fallopainæ sinistræ: scripsit Dr. Ferd. Bernard. Guil. Sommer; 4to, cum Tabula ænea. Greisswald. T. Kunike.

Mémoire sur une Methode Nouvelle de Transformation des Coordonnées dans le Plan et dans l'Espace, avec application aux Lignes et Surfaces des deux premiers degrés; par M. Georges Dostor, Dr. ès Sci. Math., Prof. de Math. à Paris. (Extrait du Journal Archiv der Math. u. Phys.) 78 pp. 8vo. Greifswald, 1856. T. Kunike.

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